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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXIX No. 2 FEBRUARY, 1929 WHOLE No. 247

ADDRESS OF WELCOME TO THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Twenty-eighth Annual Meeting at The University of Chicago, November 30, 1928.

BY ELLIOT R. DOWNING.

It is my privilege and pleasure to welcome, in the name of the University of Chicago, the members of the Central Association of Science and Mathematics Teachers to the University, for this its Twenty-eighth Annual Meeting.

It is an excellent thing for any group of specialists to meet in the atmosphere of a great university. Here about you are not only departments devoted to Science, but others equally important, devoted to literature, both ancient and modern, to art, to history, to mathematics, to philosophy, to religion. As specialists we are thus forcibly reminded that our visicn is likely to be obscured by the nearness of our own particular interest. Other spheres of human endeavor are prone to suffer eclipse because the shadow of our own looms so large.

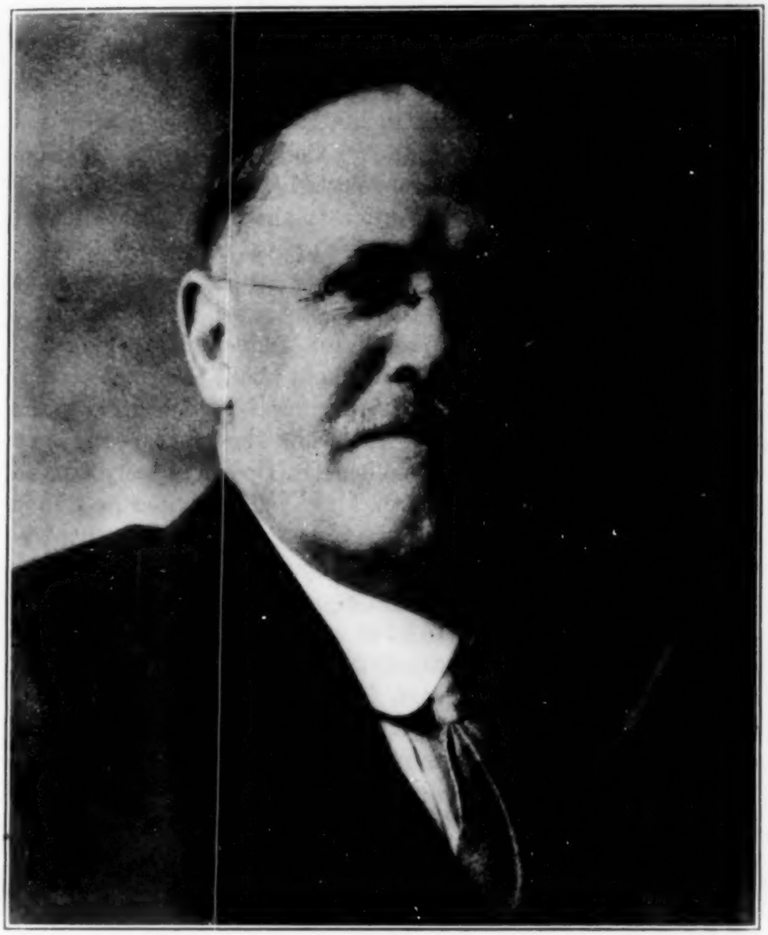
The interests of humanity, represented in the microcosm of a university, are cosmopolitan. In the total history of mankind science has played a minor role, and that in large measure, but recently. We glory in the fact that scientific discovery has added so greatly to the creature comforts of life, to the wealth and ease of humanity. Yet the majority of men are still living on the verge of misery. And it is true now as ever that the value of life is not to be measured in terms of the things a man possesses. To earn a livelihood is important only as it enables one to live a worthwhile life.

It is that problem of the value and significance of life that has absorbed the major energies of thoughtful mankind. That is the fundamental theme of literature, art, philosophy, religion. We want to know not merely how to live but why we live; not how the universe works but what lies back of its phenomena. Not merely do we crave a knowledge of things as they are but more a vision of things as they ought to be, not a knowledge alone that serves us in the span of three score years and ten, but a faith that underwrites all time; not alone a knowledge of the laws of our own meager intellects but experience that lifts us out of ourselves to fellowship with the Great Creative Intelligence. Whatever the personal beliefs of the individual scientist, he must admit that these have been and still are the spiritual aspirations of mankind. A great university is a forceful reminder of this fact. The seers, the prophets, the great teachers, the leaders who have drawn tremendous followings have been sure in their own minds of the answers to these problems.

Science has achieved a vast fund of facts. It has discovered immutable laws and given us a profound faith in the lawfulness of the universe. It has taught us much of the nature of things. It has enlarged our physical and mental horizons as its instruments have peered into immensity. Perhaps things like this are all one should expect of science. Yet the scientist, because he is an inquisitive human, must also be a philosopher. He must use his new knowledge, his new attitude of mind, his new discovered laws as a fulcrum on which to pry into the old problems. So far science has the reputation of serving largely to unsettle revered beliefs, of being destructive rather than constructive.

Signs are not wanting, however, that the constructive period is upon us. In an age of doubt we are looking expectantly for the seers who will build, on foundations of scientific data, a more certain philosophy concerning the fundamental problems.

As science teachers may we recognize our double duty, as scientists to present true science, as philosophers—and all must be such in a measure—to help think through these problems of great human interest—help construct a scientific philosophy of the meaning of life, of the significance of nature and of men's relations to his fellows. We must impart knowledge *and* wisdom.



DR. JOHN MERLE COULTER.

The death of Dr. John M. Coulter on Dec. 24 marks the passing of one of our greatest scientists. For the past forty years he has been an outstanding figure in the botanical world and has greatly influenced almost every phase of the subject, his greatness lying not only in his own scientific ability but also in his personality which inspired others to further study.

Beginning as a field botanist for the U. S. Geological Survey, he had a most active career as college and university professor, president of universities, department head, editor of botanical journal, author of numerous books of wide circulation, worker in scientific societies, and advisor in research.

His first great opportunity in life came very soon after his very early graduation from Hanover College, Indiana, when his professor of geology at Hanover selected him as his assistant on the now famous Hayden Expedition to the Yellowstone Region of the Rocky Mountains. Upon their arrival at the stated meeting place in the Rockies they pitched tent and waited for the coming of their leader, Dr. Hayden, who was delayed several days on his long trip from Washington. Meanwhile young Mr. Coulter, true to the spirit which brought about the great accomplishments of his later life, busied himself with collecting the many strange plants of the region while the other young men rested in front of their tents. When Dr. Hayden finally arrived he entered into conference with Mr. Coulter's chief and then announced that the chief of the botanical division of the expedition was unable to come and that since this young man was interested in that work he would appoint him to that position. And thus it was that Dr. Coulter came into his life work. As he journeyed into that marvelous land upon which no other scientists had ever before set foot he collected the bales of herbarium specimens, the classification of which later on formed the basis of his book "Manual of Rocky Mountain Flora." This expedition brought back the first authoritative report of the geysers of the Yellowstone.

But there were other important contacts which this Rocky Mountain trip brought about. Later when Mr. Coulter took his specimens to Washington and was busily engaged in comparing them with the National Herbarium specimens an elderly gentleman came to the table where he was working and after watching him for some time asked him about his work. The gentleman seemed interested in his account of the western trip and offered so many suggestions about the identification of the plants that Mr. Coulter recognized his superior knowledge. The gentleman proved to be Dr. Asa Gray who invited Mr. Coulter to come up to Harvard for help any time he needed it. Naturally he did not wait many days to take advantage of that opportunity and it was through the acquaintance thus formed that he

later came to prepare the famous Sixth Edition of Gray's Manual.

After his government service he returned to his alma mater, Hanover College, as professor from 1874 to 1879. Then he became Professor of Botany at Wabash College 1879-91, taking his Ph.D. at Hanover in 1882 and at The University of Indiana in 1884. The next two years, 1891-93, he was President and Professor of Botany at The University of Indiana and then for the three following years President of Lake Forest University. It was from this position in 1896 that he went to his greatest work as Head of The Department of Botany at The University of Chicago where he gathered together the distinguished botanists who have made that department so famous. It was here that he wrote most of his books. Since his retirement in 1925 he has been advisor of The Boyce Thompson Institute of Plant Research at Yonkers, N. Y., continuing as editor of the Botanical Gazette, which he founded in 1875, and as a member of the National Research Council. He had charge of the department of botany in each edition of the New International Encyclopaedia, was President of The Chicago Academy of Sciences, President of American Association of University Professors 1918, Corresponding Member British Association for the Advancement of Science, Corresponding Fellow of the Botanical Society of Edinburgh, Fellow American Academy of Arts and Sciences, and a member and frequently an officer of The American Association for the Advancement of Science, The National Academy of Science, The Botanical Society of America, and The American Society of Naturalists. He was elected to Honorary Membership in The Central Association of Science and Mathematics Teachers at the meeting at Hyde Park High School in 1922.

Professor Coulter was born in Ningpo, China, Nov. 20, 1851, spending the first few years of his life there, his parents being missionaries. It is interesting that toward the latter part of his career in the winter of 1923-24 he again went to the Orient, being sent to China and Japan by The National Association for the Advancement of Education. While there he lectured in the leading universities and other institutions of the East.

—Ross B. Wynne,
Crane Technical High School, Chicago.

MATHEMATICS AND THE PROGRESS OF SCIENCE.

By Louis C. Karpinski,
University of Michigan, Ann Arbor.

The other day I read an advertisement of a new book on the practical applications of the fairly old subject of probability. The practical author asserts that probability is "no longer the plaything for the entertainment of the erudite mind, but is a powerful instrument of practical science." This statement reflects an absolute misconception of the nature and purpose of mathematical reasoning. Fortunately it is only a few shallow scientists to whom the powerful tools placed in their hands by pure mathematical research will appear as playthings devised for entertainment. Mathematics needs no justification! The theory of probability has been studied by intelligent men as a part of fundamental truth. It happens then that the theory applies to many situations in the work-a-day world; it happens that in manufacturing the theory applies to the distribution of a large group of objects, like electric light bulbs, into groups having given characteristics; it happens that in insurance and in other industrial operations probability has its applications. But when these light bulbs are replaced by some more effective method of illumination, and when these industrial devices have long been placed in the discard, the theory of probability will continue to illuminate, will continue worthy of serious study by intellectual beings.

The world of mathematics is a reality, more enduring than the animals and plants, the changing objects and situations among which we live. To this reality the mathematician devotes his attention because he must. It is an inner compulsion.

Mathematics is closely akin to art in its methods and in its inspiration. The poet feels within himself an impulse to write in verse; the painter has before his mind's eye a beautiful picture; the architect sees a majestic building; the great musician hears a beautiful melody. And in each case the artist creates primarily for himself, to satisfy that inner demand. So it is with the mathematical, the theories which he elaborates are ends in themselves, sufficient unto themselves.

These numbers, these algebraical symbols, these geometrical elaborations, these extended speculations do correspond, it frequently happens, to diverse actual situations in the world of commerce and of science. By means of these tools the things which happen in the laboratory, in the community and in the

universe of the stars or the atoms may often be measured, studied and understood.

The fundamental mathematical theory has always developed independently of the physical phenomena which it explains. Again and again it would almost seem that the experimental scientists waited, to allow the mathematician to go ahead and pave the way. The physicists and the scientists who have made progress have approached the science, in general, with the mathematical tools prepared, with adequate mathematical equipment.

Take such simple curves as the conic sections associated through the analytical geometry with quadratic equations.

These curves first as cut from cones with varying vertex angles, the ancient Greeks studied simply and solely because these curves seemed to them logically to follow upon the circle. A whole succession of Greek mathematicians studied the properties of these curves; they learned how to draw tangents and normals and even tangents from an external point. Finally Archimedes learned how to compute the area of segments and the volumes of related solids. All of this the mathematicians did without happening to find the focus of the parabola which Pappus placed upon the map some four hundred years later. No one of these men knew or cared about any practical application of these curves.

Nearly two thousand years later Keppler, a student of mathematics and astronomy, found that the orbit of the earth was not circular. Keppler turned naturally first to the ellipse with whose properties, as a serious student of the mathematics of his day, he was familiar. So he was able to find that the paths of the earth and other planets are ellipses with the sun as one focus. Keppler was able through his familiarity with the conic sections to enunciate the three theorems of planetary motion. This knowledge of the properties of the conic sections Keppler obtained as a student of mathematics. Neither the Greeks who began these studies nor Keppler when he studied the Greek developments had any notion of their application to astronomical problems. Had Keppler not had this background of mathematical information and training the world would have waited considerably longer before the astronomical facts would have received their correct interpretation.

Not long afterwards Galiteo Galilei wished to investigate by

experiment the motion of a falling body. Here again a simple mathematical law was found to explain the motion. Galilei was able to show that the space passed over in successive seconds was proportional to the successive odd numbers. As a result the total space passed over by a freely falling body is given by the quadratic equation $s = 16\ t^2$. This of course is connected with the beautiful fact that the sum of first n successive odd numbers is n^2.

Upon these foundations of the conics and their properties and of the planets and their motions Isaac Newton built his universe. Essential to his formulation and explanation was not only the mathematical work on the conics, the work on the planets and on falling bodies as given by Keppler and Galilei, but equally the new tool of analytical geometry which had just been placed in his hand by Descartes. The three laws of planetary motion as enunciated by Keppler became special instances under a more comprehensive law as given by Newton and because Newton's equations are more powerful and more comprehensive than Keppler's, for that reason Newton is a greater genius than Keppler.

Keppler and Galilei and Newton are universally regarded as great scientists, not because of their remarkable powers of observation but primarily because back of the observed facts these men saw mathematical formulas. Not only are the observed facts subjected to the mathematical formulae but out of the mathematical formulation comes new light upon the observed facts with new facts and new aspects revealed only by observation again in the light of the formula. The real value of a formula is revealed not in its explanation and interpretation of what has happened but rather in its power to guide the intelligent observer to new truths.

Today the automobile engineer uses the parabola to fashion the automobile headlight; the architect uses the parabola to build the auditorium and to build his finest bridges; the student of projectiles begins with the parabola. Progress is made by the use of these geometric curves with simple algebraical properties. While these curves were originally studied as simple geometrical exercises, the teacher today who does not point out their many uses in practical affairs misses a great opportunity to impress upon the pupil the part of mathematics in the progress of science and to impress upon the pupil the universe as ruled by mathematical law.

As I have said, the outstanding characteristic of a great physicist or astronomer is the ability to interpret and extend his observations by means of mathematical formulas. Only rarely is there an exception to this rule. Such an exception was doubtless Faraday whose contributions to the science of electricity press in upon us wherever we live. However Faraday himself knew that lack of familiarity with mathematics was a serious drawback. Upon Faraday's observations Clark Maxwell reflected and evolved the famous Maxwellian equations. As an almost immediate magnificent product of the mathematical consideration came the electro-magnetic theory of light. Again twenty years later upon the basis of the mathematical formulation the German Hertz regarded the phenomena anew, under the light of the mathematical formulas, and the marvels of wireless electricity began to appear.

These mathematical speculations and their mathematical consequences created a new heaven and a new earth, for the old physics is passed away. The new heaven is mathematically determined to be finite while the new earth consists of mathematical combinations of a hydrogen nucleus with attendant electrons. However, while these mathematical speculations so intimately connected with the relativity theory are beyond the ordinary scientist, yet everyone who listens to the radio should recognize also the voice of the mathematical formula.

By the recent development in the new physics the work of Maxwell takes a place alongside Newton's Principia. In these works we have the universe subjected to that mathematical formulation. A great body of physicists have contributed to the mathematical extension of Newton's universe as expressed in the Einstein emendations. In this new universe the great groups of phenomena such as those connected with light and electricity and magnetism are treated simultaneously as different aspects of similar phenomena. The same equations govern different phenomena and often give remarkable analogies. Chemistry and astronomy and even medicine cannot remain aloof from these mathematical considerations of the electrons. No one can see or prophecy the end but one can say with confidence further progress will be reflected in further mathematical formulation.

Doubtless the Maxwell equations represent the highest contribution of mathematics to the understanding of the universe in which we live. Yet the same type of illumination is afforded

by diverse other fields of pure mathematical speculation. For many centuries the students of mathematics labored with the problems arising out of the representation of numbers. When it was found that negative numbers could be represented by points on a line symmetrically placed with respect to an origin, representing O, a great step was made for advance in the theory of equations. At the same time the notion of a vector was suggested, so that by consideration of the line segment as having magnitude and direction a powerful tool was given to the physicist. It was comparatively easy for the mathematician to see that the $\sqrt{2}$, $\sqrt{3}$ and other quadratic irrationalities would be represented by absolutely definite points upon this line of real numbers. The fact too that to each real number corresponded a definite point upon this line also offered little difficulty.

In this way the negative and irrational solutions of equations came to be accepted as on a par with solutions in rational numbers. However, the complete acceptance of the complex number waited upon some graphical representation. To this problem no less than three mathematicians, the Norwegian Kaspar Wessell, the great German scholar Gauss, and the Frenchman Argand found independently the solution, the complex number diagram which is known today even to our high school students.

For the theory of algebraical equations this conception gave to that great genius Gauss the suggestion for the proof of the theorem that every polynomial in x with real and complex coefficients has a root, the so-called fundamental theorem of algebra. But it was not long before the physicist discovered that this new speculation of the mathematician afforded elegance and simplicity in the consideration of diverse problems of nature. Thus the theoretical treatment of alternating currents is made easily intelligible by a Steinmetz, employing the symbolism and the methods of operations with complex numbers.

Progress in science has been preceded by progress in mathematics. Certainly so far as the science of physics and astronomy is concerned it is true that progress has been expressed in mathematical formulas. The laws of physics and the laws of planetary motion are mathematical statements concerning the physical phenomena. Today even the biologist and the student of medicine as well as the chemist are looking to the physicist for an attempt at a mathematical formulation of the phenomena of the test tube, of the growing plant and the human body.

For the secondary school teacher the question is vital, can the

student study physics and other science first and learn the necessary mathematical formulas and methods as the need arises. The answer of history is absolutely and emphatically, No. Had Keppler not been familiar with the mathematical theory of the conic sections he would not have been able to formulate the laws of planetary motion. Had Newton not been acquainted with the mathematical advances of his day, and the geometry of the Greeks, his conception of the universe could not have been formed or formulated.

Helmholtz made enduring contributions to the theory of sound because as a young student at Berlin he occupied himself with mathematics and physics. When his work in medicine brought to his mind the problems of sound Helmholtz had the indispensable preparation and he was able to solve problems which would have been for him forever unsolvable if he had been required to go back to build up the theoretical foundation.

Maxwell had that thorough mathematical preparation which enabled him to see the formulas back of the electro-magnetic phenomena. A whole host of recent physicists like Michelson and Einstein have had such a profound grasp of mathematics that the new physics, a mathematical creation has emerged. The mathematical training of these men began in their early student days and it has continued ever since.

For the boys in your high school the lack of the instruction in elementary algebra, in geometry, in elementary trigonometry will absolutely bar their way to the sciences; it is as serious for them as lack of mathematical training is for the physicist today. For 99 out of 100 in college it is too late to turn back, to pick up that elementary instruction in the mathematics which today, more than ever, is essential for progress in science. "Time never turns back" and the student who waits to learn his mathematics and the physics, the theory, as he needs it, that student will never find it necessary. Progress will not wait for him.

It is not possible in the limited time to touch upon many of the contributions of mathematics to progress. In economics, in many phases of biology, in insurance, in almost all phases of engineering mathematics plays an important role. Newton would be surprised and pleased that his binomial expansion proves so usual in modern business. Leibniz and Newton and Descartes would congratulate themselves upon the wide uses found for the methods of analytical geometry and the calculus. The mathematicians of Greece and India and Arabia and Europe

who for pure love of science evolved the trigonometry would be surprised to find their tables and their methods in daily use in the great factories and in the workshops.

But no one of these thinkers of past ages would feel that his search for mathematical truth needed the practical application to justify his study. Even in those ancient days the circle and the parabola and the ellipse were realities, and the numbers of arithmetic and the symbols of algebra and geometry and trigonometry and calculus created a world whose reality cannot now be disputed.

Today more than ever number rules the universe; and appreciation of the universe in which we live as ruled by number and by form is cultivated by the proper study of mathematics. Number and form are guiding principles in all reasoning involving quantitative relationships. Even in the fields of ethics and philosophy and religion the serious student is frequently compelled to become precise and definite by mathematical illustration. Thus it is related that when Plato lectured on beauty some of the listeners protested because he began with geometry. And today for any intelligent comprehension of the economic foundations of our society and for any slight understanding of the universe of the stars or the atoms, for appreciation of many of the most fundamental developments which distinguish the reasoning creature, man, from the dumb brutes, the study of mathematics is essential. Show to your pupils that mathematics opens to their minds many doors which will in all likelihood forever remain closed if in the high school the opportunity to begin this study is neglected.

INCREASED PREPARATION REQUIRED BY LAW SCHOOLS.

Of 176 law schools in the United States and 10 in Canada embraced in the annual review of legal education for the year 1927-28, by the Carnegie Foundation for the Advancement of Teaching, 14 full-time law schools in the United States and 1 full-time school in Canada require for graduation more than five academic years of work beyond high school. In the United States 56 full-time schools require five academic years, and 6 schools require three or more academic years. Part-time schools in the United States requiring three or more academic years number 70, mixed full-time and part-time schools number 20, and 10 schools have a law course requiring less than three academic years for graduation. Of the remaining full-time schools in Canada, four require for graduation five academic years of work beyond secondary school, and five part-time schools require three or more academic years beyond completion of high school.

A NEW DESIGN OF ELECTROMAGNET ENERGIZED WITH THERMOELECTRIC CURRENT.

By Paul E. Klopsteg,

Development Laboratory, Central Scientific Co., Chicago, Ill.

Electromotive forces and currents produced by thermocouples are as a matter of common experience very small. They are measured in microvolts or millivolts, and milliamperes, respectively. That the current is small is, of course, the result of resistance which, in most thermocouple circuits used in practice, is relatively large. A circuit having a resistance of an ohm allows a current of one milliampere to flow for each millivolt of electromotive force, and currents of this order of magnitude produce no pronounced mechanical effects. To enhance the effects of thermoelectric currents, thermopiles of large dimensions, such as that of Noë, have been on the market in Germany for many years. With a thermopile of this type a gas burner could be made to ring an electric bell or even charge a storage cell. To the student there is nothing of the unusual or spectacular in such a demonstration.

Wunder[1] describes an arrangement consisting of an electromagnet winding of a few turns of copper rod 1 cm. in diameter, the winding being made to fit a U-shaped iron core of the usual type. The current through this winding is produced by an iron-nickel thermocouple secured to the two ends of the copper circuit. Wunder states that the magnet is capable of supporting a heavy latchkey. Compared with earlier demonstrations this one is striking and may be expected to stimulate the student's interest. Another demonstration piece described by Merkelbach[2] employs a bismuth-antimony junction with a copper circuit in the form of an elongated loop. This loop is mounted with its plane vertical and a magnetic needle is mounted within the loop so that it responds to the current flowing through the circuit. Various other similar pieces have been described both in the literature and in the catalogs of German apparatus firms.

Volkmann[3], struck by the possibilities revealed in the earlier demonstrations, designed an electromagnet to be energized by thermoelectric current which should exert greater pull than that of Merkelbach. He succeeded in producing a magnet which, when the thermocouple was heated with a blast burner, was

[1]Wunder, ZS. f. phys. u. chem. Unterr., XXIV, 1911, 224.
[2]Merkelbach, ZS. f. phys. u. chem. Unterr., XXVI, 1913, 299.
[3]Volkmann, ZS. f. phys. u. chem. Unterr., XXVIII, 1915, 25.

capable of lifting somewhere between 10 and 20 kg. The manufacturers of the Volkmann apparatus supply it with a 5 kg. weight attached to the armature.

In studying the demonstrations of Wunder, Markelbach and Volkmann the writer became convinced of the possibility of a really spectacular demonstration with thermoelectric current. He first constructed a magnet of Volkmann's design and found 10 kg. to be the maximum load which it could sustain when one junction was immersed in tap water and the other heated with a Meker burner. He then designed a lifting magnet with particular attention to securing correct shapes and relative dimensions, and proper relative placement of the magnetic and electric circuits, to develop maximum pull for the quantity of iron and copper used.

FIG. 1.

In the form which proved highly successful the electric circuit consists of a single turn of square copper bar of large cross sectional area, formed into a circular turn. The ends of the turn extend outward a few centimeters. Between these ends is silver-soldered a copper-nickel alloy bar. Thick copper plates are silver-soldered to the outer sides of the ends of the copper

bar. The general arrangement of the electric circuit as well as the body of the magnet and armature are shown in Fig. 1. (In the figure the alloy bar is hidden by one of the plates.) The copper plates serve as heat transfer means which have large thermal conductivity, large area to receive or dissipate heat and large area of thermal contact through which heat can be delivered to or withdrawn from the junctions of the thermocouple.

Both magnet and armature are machined from soft iron of high permeability. In order that the magnet may exert maximum pull it is essential that the contact surfaces of magnet and armature be ground plane and that the two surfaces be in close contact over their entire area. This makes necessary the avoidance of nicks around the peripheral corners of the contact surfaces of the magnet and armature which would cause slight separation of these two surfaces.

A groove of rectangular section is machined in the face of the magnet against which the armature fits, and this groove receives the circular turn of copper. The latter is firmly clamped in place with two screws. Although the inside surfaces of the groove are coated with baked japan for insulation there is no great need for the precaution of insulating the copper bar because of the very low potential differences in the copper circuit. Magnet and armature are provided with stout hooks.

Fig. 2 represents the apparatus as used in a demonstration. One of the copper plates is immersed in a beaker of water and the flame of a burner is played on the other. After perhaps 15 seconds the armature is tightly held. When the heating has been continued long enough to establish a sufficient temperature difference between the junctions a weight hanger may be suspended from the armature, and the load applied.

In the first experiment the magnet sustained a load of 48 pounds with no sign of detachment of the armature. The writer then found that he could suspend his own weight (190 pounds) without pulling the armature off. The next experiment was to measure the breaking pull with an electromagnet tester of standard design. It was found that a load in excess of 400 pounds was needed to detach the armature.

It is interesting to determine how much current flows in the copper bar to produce a magnetic pull of this magnitude. The first method of finding this current is to compute the electromotive forces from estimated temperature differences, and the resistance from the dimensions of the circuit. Assuming a

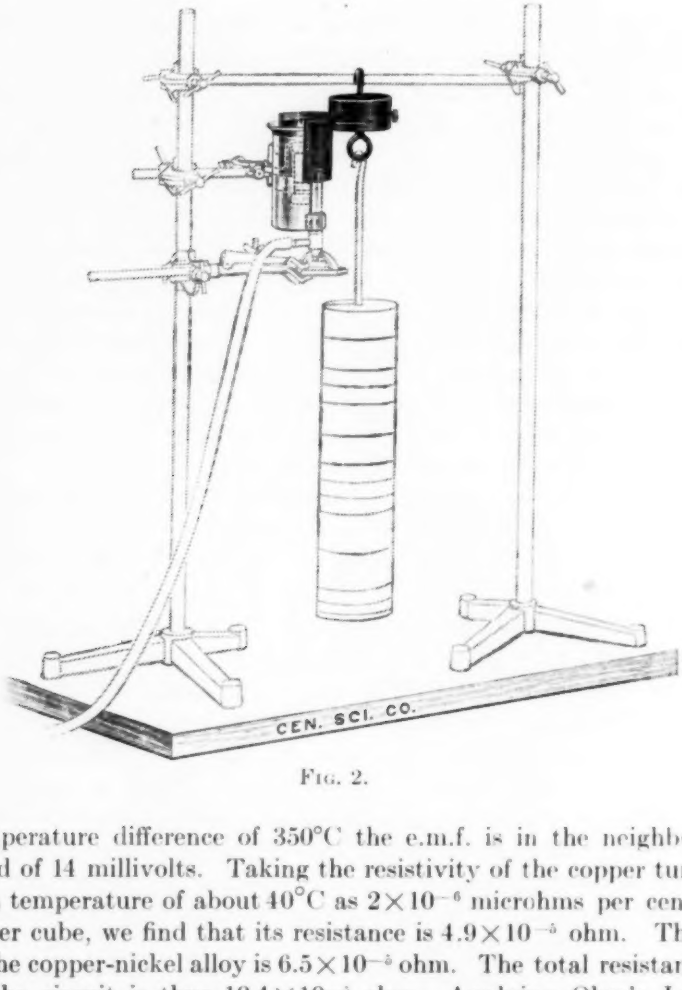


FIG. 2.

temperature difference of 350°C the e.m.f. is in the neighborhood of 14 millivolts. Taking the resistivity of the copper turn, at a temperature of about 40°C as 2×10^{-6} microhms per centimeter cube, we find that its resistance is 4.9×10^{-5} ohm. That of the copper-nickel alloy is 6.5×10^{-5} ohm. The total resistance in the circuit is thus 10.4×10^{-5} ohm. Applying Ohm's Law to the above mentioned electromotive force and resistance we find that the current is approximately 135 amperes.

This value seems so astonishingly large for the current developed by a single thermocouple that an indirect check measurement was made. A coil of 100 turns was wound to fit the groove in the magnet body. Direct current, measured with an ammeter, was supplied to this coil. It was found that a current of 1.4 amperes (i. e., 140 ampere-turns) sustained a load in excess of 485 pounds, showing that the computed value of the current was approximately correct.

The result of the test with the 100-turn coil, no less than the first, was astonishing. The resistance of the coil is slightly larger than 1 ohm. When this is connected across a single dry cell a current of 1.4 amperes flows. Thus, the magnet with a 100-turn winding, with a single dry cell supplying the magnetizing current, is capable of sustaining the weight of three men of 160 pounds each.

There comes to mind the showmanship of Otto von Guericke and his Magdeburg hemispheres, which two teams of eight horses each, pulling in opposite directions, could not pull apart—a great extravagance in horses! As a spectacular demonstration, ropes might be attached to magnet and armature, and, having energized the coil with a dry cell, let six boys have a tug of war—three on each side—with the magnet between them.

The experiment with the 100-turn coil shows the correctness of design of the magnet. It shows further that the design of the magnet, no less than the design of the electrical circuit[4], is responsible for the surprisingly large pull produced by the current from a single thermocouple.

[4]Patent application has been filed to cover the features which are responsible for the exceptional performance described in this article.

THE DISPUTED CHACO.

The Paraguayan Chaco area in dispute between Bolivia and Paraguay comprises a region larger than the States of New York and Pennsylvania combined. It is a vast territory inhabited largely by primitive Indians, and it is not to be confused with the better known Argentine region commonly called "Chaco."

Describing a journey up the Parana and the Paraguay to this vast and little known region, which so long has been a subject of disagreement, William R. Barbour wrote to the National Geographic Society:

"The Chaco was once a shallow inland sea, with its eastern border about where the river now flows. This sea eventually dried up, leaving vast swamps, with a salty or alkaline grayish sandy soil devoid of rocks. The river is to-day the dividing line, even the plant and animal life differing on its two sides.

"I was told that a few miles east of the river the country consists of high rolling hills clad with open forests of cedar and other valuable cabinet woods, and with running streams of clear water in the valleys.

"Our destination was Puerto Casado, some three hundred miles north of Asuncion and only a few miles below the Brazilian frontier. We reached it the next noon, leaving our ship to plow on several hundred miles farther, to its final stopping place at Corumba, Brazil, and catching it again on its return trip.

"Puerto Casado is the site of an old extract plant, small sawmill, and town of employees. The entire establishment, with seven million acres of wild land, extending across the Chaco to the Bolivian frontier, belongs to one Argentine family."—*Geographic News Bulletin.*

CHEMISTRY TEACHING IN NEBRASKA.

By B. Clifford Hendricks

AND

John S. Chambers,

University of Nebraska, Lincoln, Neb.

Chemistry has, no doubt, been taught in Nebraska ever since the state has had high schools or colleges. The story of this course in Nebraska's schools has been one of ups and downs, the details of which no one has, as yet, attempted to follow.

The present paper does not presume to go back into history, for the writers find very little of such history available. Rather, it is attempting to make the results of a recent investigation[3], under the direction of the Committee of Chemical Education of the American Chemical Society, a matter of record for some future historian of "Chemistry Teaching in Nebraska."

Source of Data.

Total four-year high schools in Nebraska (1926-27)	530[1]
Number of high schools offering chemistry	126[2] or 23.7%
High schools to which questionnaire[3] was sent	444 or 83.0%
Total replies received	145 or 32.6%
Replies from schools teaching chemistry	55 or 43.6%

How Generally Is High School Chemistry Studied?

Total enrollment in Nebraska high schools[4] (1925-26)	60,106
Enrolled in chemistry[2] (fall of 1925)	2,286 or 3.6%
High school pupils reported in questionnaire (46 schools)	16,815
High school chemistry pupils reported in questionnaire (46 schools)	1,237 or 7.3%
Per cent of high school pupils, who are chemistry pupils, in the whole U. S.[5]	7.42%
Average high school chemistry registration (35 schools) last 5 years	880
Current high school chemistry registration same 35 schools, 1926-27	1020
Increase of current enrollment over 5 years average	16%
High schools offering chemistry for 1913-14[6] (174 schools)	47%
High schools offering chemistry for 1925	23%
Registration for high school chemistry second semester (1926-1927) (46 schools)	1,137
First semester students who failed in chemistry	131 or 10.6%
Chemistry taught in fourth year of high school	47%
Chemistry taught in third year of high school	9%
Chemistry taught in either year of high school	44%
Chemistry taught as elective	75%
Chemistry taught as required subject	25%

[1]Nebraska Educational Directory, 1926-27.
[2]Records of North Central Association's representative for Nebraska.
[3]Sent out spring, 1927, under auspices of National Committee of Chemical Education, American Chemical Society.
[4]Personal communication, state superintendent's office.
[5]Bulletin No. 7, Bureau of Education, 1924. (Data for year 1922.)
[6]B. Clifford Hendricks, Physics Teaching in Nebraska, Middle West School Review (1915).

Pupils in chemistry (46 schools), first semester, 1926-27	1,238 or 27 per school
Second semester	1,137 or 24 per school

What Does Chemistry Instruction Cost?

Equipment, September, 1926:		
Invoice for 55 schools	$54,330	$988.00 per school
Invoice for 1191 pupils	50,180	42.15 per pupil
Annual budget for 42 schools	7,173	170.00 per school
Annual budget for 1033 pupils	6,748	6.53 per pupil
Annual cost, including 6% on overhead		9.06 per pupil
Library:		
Journals, general for 73 schools	134	2 per school
Journals, chemical for 49 schools	21	1 for 2 schools
Allowance (annual):		
General books and magazines, 43 schools	$402.00 or	$9.52 per school
Total science books in library, 70 schools	3,454 or	49 per school

What Chemistry Course Is Followed?

The outline of minimum essentials from the American Chemical Society's Committee on Chemical Education, 44 schools report 70% are following it and 30% are not.

Are There Teachers Prepared to Teach It?

	College Credit hr. per Teacher	Range from
Preparation of: Those (44) actually teaching it:		
In physics—Average credit	9.4	0 to 30 hr.
In mathematics—Average credit	12.7	0 to 28 hr.
In chemistry—Average credit	21.1	5 to 60 hr.
In education—Average credit	22.7	12 to 54 hr.
Those (14) who could teach it, but do not:		
In physics—Average credit	9.3	8 to 15 hr.
In mathematics—Average credit	14.0	0 to 32 hr.
In chemistry—Average credit	15.3	0 to 34 hr.
In education—Average credit	25.6	15 to 36 hr.

Why Is It Not More Universally Taught?

Of 81 schools reporting an answer to this question, 13.6% reply "Too much expense"; 17.3% say, "No call for it"; 32.1% give "Not equipped for it"; 24.7% say "Teaching staff too small"; 3.7%, "No teacher for it"; 11.1%, "No funds for it"; 11.1%, "Other subjects such as physics, biology and agriculture are more important"; 9.9%, "Dropped chemistry in 1917"; 5.0% report "'No chemistry' is a sort of tradition in our schools"; and 1.2% say that "College teachers discourage high schools from teaching chemistry."

Does the High School Chemistry Student Take College Chemistry?

Number high school and academy graduates for Nebraska (1926)[4]	11,300
Number high school chemistry students (fall 1925)[2]	2,286
Number freshman college chemistry students who have had high school chemistry (fall 1926)[3]	539

Nebraska high school chemistry students who continue with college chemistry	1 out of 4.2
Michigan high school chemistry students who continue with college chemistry[7]	1 out of 13

What of College Chemistry?

Institutions in Nebraska offering college work (1926-27)	26
Institutions replying to questionnaire[3]	20
Institutions offering college chemistry	19
Total student enrollment for colleges offering college chemistry (1926-27)	16,389
Students registered (1926-27) in first year chemistry who have had a year of high school chemistry	539
Total students registered in all college courses in chemistry	2,728
Per cent of Nebraska's college enrollment taking college chemistry	16.6%
Median percent of enrollment, 259 colleges and universities in 31 states of U. S., taking college chemistry for year 1926-27[9]	26.2%
Total Nebraska students majoring in college chemistry (1926-27)	191
Total Nebraska graduate students in chemistry (1926-27)	26
Per cent of Nebraska's enrolled college students majoring in chemistry (1926)	1.2%
Median per cent of enrollment in 245 colleges[9] majoring (1926-27) in chemistry	3.5%

What Does College Chemistry Cost?

Invoice for Nebraska colleges for chemicals and supplies (September, 1926)	$307,000.00
Invoice for Nebraska chemicals and supplies average per student	112.00
Median invoice for apparatus and chemicals per student (1926-27) for 259 colleges[9]	70.68
Nebraska's annual budget for chemicals and apparatus (1926-27)	$ 27,150.00
Average per student	9.85
Median annual budget for chemicals and apparatus per student for 259 colleges[9]	11.88
Average cost for Nebraska colleges, including 6% overhead on invoice, per student in chemistry	16.67
Average cost per chemistry student for twenty colleges distributed over the United States[8] (1926)	12.68
College chemistry libraries (15), annual expenditure (1926), for books and magazines	2,010.00
Average expenditure per year per library	133.40
Cost of library reading material per year per student	.78
Median annual expenditure per college for books and magazines for 258 colleges[9]	220.00

College Chemistry Instructional Staff.

Total chemistry instructional staff for 19 Nebraska colleges (1926)	90
Estimated number half time instructors	40
Average number chemistry students per full time Nebraska instructor	39
Median number chemistry students per instructor for 245 colleges[9]	40

How Is Chemistry Taught in Nebraska?

High school chemistry is not offered in as large a per cent of Nebraska's schools as it was a few years ago (1913). The regis-

[7] R. K. McAlphine, School Science and Mathematics, 28, 154 (1928).
[8] N. M. Grier, School Science and Mathematics, 26, 449 (1926).
[9] *Com. Chemical Educ. Jour.* Chem. Educ., 4, 911-913 (1927).

tration, however, seems to have increased during the past five years in the schools in which it is offered. The per cent of high school students studying chemistry in Nebraska is not as great by more than half as are taking that subject in the United States. A fair per cent of these students, however, continue chemistry in college. The chief argument against chemistry, by schools not offering it, is its cost. The teacher supply available seems better than the demand.

College chemistry, as taught in Nebraska, is costing, if anything, less per student than in most American colleges. The student is getting about the same share of his teacher's time as in other colleges. The number of Nebraska students majoring in college chemistry is relatively fewer than in the country as a whole. Nebraska colleges do not offer their chemistry students the library facilities in up-to-date books and magazines that most other colleges do.

A SIMPLE BUT INSTRUCTIVE PHYSICS EXPERIMENT.*

By Harvey A. Zinszer, *Hanover College.*

Determining "g" with a Piece of Pipe: A meter length of ordinary water or gas pipe must be provided. Drill a quarter inch hole about twelve centimeters from each end of the pipe. Through these holes, insert a piece of triangular file long enough to protrude several centimeters on both sides of the pipe. The protruding pieces of file will serve as knife-edges about which the pipe may swing. Procure two large nuts of appropriate diameter and fit one of them permanently to one end of the pipe; the other should slip freely over the pipe and be fastened anywhere between the knife-edges with a set screw or with similar wedges on opposite sides of the pipe, thus serving to vary the center of mass of the system. Two uniform boards clamped to a high table or shelf, together with two similar pieces of smooth, flat glass will serve as a support and bearings.

Using this device as a reversion pendulum and observing the periods about both knife-edges and the distances between the center of mass and the knife-edges, we can determine the acceleration of gravity by

$$g = \frac{4\pi^2(x^2 - y^2)}{xt_x^2 - yt_y^2}$$

where x and y are the distances from the center of mass to the knife-edges, while t_x and t_y are the periods of the pendulum about these respective knife-edges. Results accurate to one-tenth of one per cent were obtained by Hanover students with this crude apparatus which cost practically nothing. The theory of this experiment can be found in any textbook on general physics. Excellent references are Watson's "Practical Physics," published by Longmans, Green and Company, also Franklin and MacNutt's "Mechanics and Heat," published by Franklin and Charles, Lancaster, Pa.

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*From a paper read before the Indiana Physics Teachers' Club at Franklin College, November 9, 1928.

MUSHROOMS AS GLACIAL RELICTS.

By V. O. Graham,
4028 Grace St., Chicago.

The presence of plants ordinarily associated with southern vegetation in a community with other plants associated normally with northern vegetation has caused much wonder by visitors of the dune lands. The same situation prevails in tamarack bogs, but these are more rarely visited; not alone because of their soft undersoil, but because of the usual presence of "poison sumac," a small tree similar in its toxicity to poison ivy.

The forests of West Central Michigan are climaxed by Beech-Maple-Hemlock; Northern Michigan and Canada, by Spruce-Balsam fir. The landscape in the Hudson Bay latitude is occupied by low growing plants with an abundance of mosses, lichens, etc. This is the tundra area. Descriptions of the flora of this region rarely mention the fungus, but a few statements are to the effect that fungi are abundant. It would be extremely interesting to have a complete list of such species, in order that we might, with greater certainty, say what plants of our southern flora have northern affinities.

Our most authentic taxonomic accounts of the larger fungi are those by C. H. Kauffman, which include the Michigan northern peninsula, and the New York State Museum reports by C. H. Peck. With such comparative data as we can obtain from the habitats of these plants, it is possible to formulate a plausible historical sequence. A number of members of the Heath family, the pitcher plant (Sarracenia purpurea), sundews (Drosera rotundifolia and Drosera longifolia), northern willow (Salix candida and Salix pedicellaris), cranberry (Vaccinium macrocarpon), holly (Ilex verticellala and Nemopanthus mucronata), and tamarack (Larix laricina) are vascular plants with strong northern affinities.

Our bogs are inhabited by these plants, and beneath them on the moss carpet are fungi with northern affinities. Bogs, especially where the entire depression is occupied by their vegetation, are likely to be matured. If however, they occur at one edge of a larger depression—a small lake—they may continuously renew their youth by adding new zones of vegetation upon the floating mats of water lily rhizomes, etc. Such a forward-moving bog presents a vegetative zonation of remarkable interest, and makes possible the appearance of a series of fungi communities.

The first type of bog in the smaller depression began with the melting of a great unit of ice leaving a small lake after the retreat of the glacial ice sheet to the northward. The slow return of the plant associations toward the north—the tundra but a short distance behind the retreating ice—were followed in succession by the Spruce-Fir, Beech-Maple and Beech-Maple-Tulip forests. Associated with the tundra and the Spruce-Fir are many bogs somewhat different, but in the main comparable with the bogs of northern Illinois. In bogs, a great number of seed plants, mosses, and fungi have remained dissociated from their former affinities by their advance to the northward.

The bog associations, because of the very unusual physical environment, have successfully remained and withstood the invasion of the next and next southern zone of plants like protected islands in an advancing sea.

Two types of northern inhabitants are found in the bogs of Illinois; those that are in a substratum of the same kind as that in the northland, and those that are not in the same kind of a substratum. Belonging to the first of these is a considerable list of sphagnum-inhabiting fungi that may be found in any place that sphagnum or other bog moss may form mats. Hygrophorus speciosus, H. miniatus, Russula fallax, Boletus spectabilis, Galera hypnorum, Omphalia fibula, Cortinarius cinnamomeus, Calvatia saccatus, and Thelephora initibus, as far as our present scant information concerning them will permit a conclusion, seem to belong to this group. Belonging to the second are the inhabitants of the northern conifer forests such as Cantharellus infundibuliformis, Cortinarius flexipes, Cortinarius decipiens, and possibly Hygrophorus speciosus and Cortinarius cinnamomeus. These furnish a remarkably interesting group, and require a different explanation from the first group. The Sayer bog, northwest of Volo, contains all of the species here mentioned. Part of them may be found in any of our bogs.

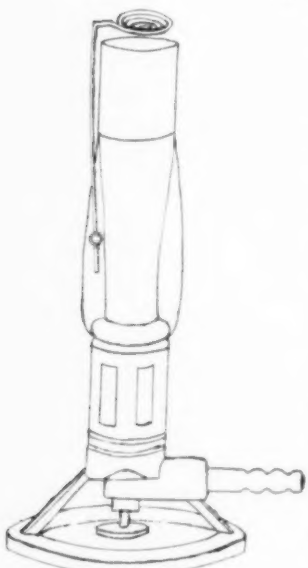
The presence of the first group may be explained by pointing out how readily the spores are transported by the wind. A common spore size is 1/3000 of an inch, which is smaller than the usual suspended dust particle. Mt. Krakatoa exploded in 1883, sending dust to a height of seven miles. For three years very colorful sunsets resulted from the suspended dust. Geographers estimate that the dust floated seven times around the earth. In the light of such an illustration, it would seem safe to say that spore dissemination may cover almost any distance on the

surface of the earth, and that a species may be found anywhere that conditions are suitable for its germination and development. The conditions in bogs and sphagnum tundras are similar enough to permit these species to be found in bogs or tundras. No accurate check—known to the author—has been made of the tundra, but these species are listed in bogs in the extreme northern part of Michigan.

The presence of the second type in our Illinois bog seems best explained by listing them as glacial relicts. These seem to have maintained their existence in this way in a more southern position than would be expected. In the latitude of the beech-maple association are, therefore, found plants normally found in the spruce-balsam association of the north.

A CONVENIENT SODIUM FLAME.

By G. G. Kretchmar,
Walla Walla College.



A device for producing a sodium flame of considerable intensity and which is a convenient laboratory source of monochromatic light is shown in the accompanying sketch.

It consists essentially of a spiral of No. 14 nickel wire supported so as to hold sodium chloride or other salt over the flame of a burner of the Fisher or Meeker type.

The spiral is wound in the form of a flat surface about two centimeters in diameter as closely as possible, and afterward sprung slightly so as to be somewhat cup-shaped. It may be conveniently supported by means of a small binding post of the American type, which is fastened to the burner. The flanges which are on the Fisher burner afford a very convenient means of attaching the binding post.

In operation the sodium chloride fuses and wets the bottom of the nickel spiral where it readily vaporizes and gives an intense sodium flame for a considerable length of time without renewal of the salt.

SUPPLEMENTARY AIDS IN TEACHING GENERAL SCIENCE.

By Ellis C. Persing,

School of Education, Western Reserve University, Cleveland, Ohio.

Textbooks supply the teacher and pupil with the basal subject matter or they may serve as an outline course. They are necessary and I am not urging any other materials to take their place; but they are, more or less, static. Even with constant revisions it is impossible to keep them up to date with the latest developments in science. This is one reason for urging supplementary materials which will help relate science to the experiences of the pupils.

Further teaching of general science has been introduced into our schools so rapidly that teachers are often confronted with the problem of securing adequate materials. Until proper rooms and minimum supplies are provided by the boards of education, teachers may secure a wealth of materials without cost by simply requesting them from various sources.

Even though schools are equipped with the regular modern apparatus and supplies the progressive teacher is seeking the best available periodicals, reference books, government bulletins, materials from commercial firms, pictures, exhibits, lantern slides, and films. The tendency is and will be for some of these special teaching aids to become regular standard equipment and materials.

The ever increasing demand for materials in connection with units of instruction in several of the subjects in our schools has led to this attempt to find, test and classify the visual and other materials as special teaching aids from commercial concerns.

The evidence of a real need for such materials came in the form of requests from teachers not only in Cleveland but from schools in many other cities. Further and more urgent demands for teaching aids were realized in preparing the tentative courses in Elementary Science and in making lists of materials for other Science subjects. Again demands were made on the writer by the students in his course "The Teaching of Elementary Science," offered in the School of Education for actual materials for certain units.

A list of firms was obtained from the advertisements in ten of the popular magazines. Letters were sent to these firms to determine what materials were available to the schools and what was the nature of such materials. Reference to lists already

available such as Roller, D. E., University of Oklahoma Bulletin, *Sources of Free Materials for Use in the Teaching of Natural Science;* Frank, J. O., *How to Teach General Science*, pages 196-223; Griffith, Fay and Lott, Mamie O., *Illustrative Materials Useful in Elementary Grades and Junior High School*, was made for other sources. Letters were sent to these companies to learn if these materials were still available and to find if new aids had been added to their lists.

The replies were sorted into the following groups: Those that did not have materials or did not wish the name to appear in our list; those that had free materials; and those that made a small charge for their exhibits.

The materials are being examined and checked to the following criteria which were set up for this purpose:

(a) Materials. Materials must help illustrate a certain lesson or field of subject matter.

(b) Subject Matter. Subject matter must be accurate of statement. Signed articles or bulletins giving the author's name were given preference. For example: The splendid pamphlet entitled "The Magic of Communication," by John Mills, is a most fascinating and accurate science story.

(c) Reading Materials. Reading materials must not contain propaganda.

In some cases these materials were tried out in the classroom before listing. Only those which have been judged most helpful to teachers and pupils have been included. When materials were discovered that could be used in connection with certain units, permission to include them in our list was obtained. It was often necessary to send two or more letters before definite statements granting the right to suggest their materials was given. This means that the companies whose names appear are willing to comply with the teacher's requests so long as their supplies last.

New materials are constantly appearing and it may not always be possible to obtain the items listed since firms change their advertising materials frequently, but others equally valuable may usually be obtained from the sources listed here. If the supply of items requested has been exhausted, the firms will often make substitutions as a special favor to the teacher. Therefore it is advisable to make requests for specific materials stating the unit for which they are to be used so that new items can be sent to meet these needs.

Unless materials of this kind are classified in some way so that they are easily available, teachers are not likely to use them. Therefore, it is important to decide upon a system for filing and storing them as they are received. For this reason the system which I have worked out for our department is given somewhat in detail. It is a simple but effective plan. As the booklets, pamphlets, charts and exhibits came in they were examined and placed under the subjects to which they pertain and the specific sub-topics under those subjects. Each article was also appraised as to its suitability for the different branches of science, such as elementary science, general science, biology, physics and chemistry.

In order to locate our materials quickly we had to have a system of filing cards. Consequently, as the materials were received and classified the information was typed on to filing cards 5 by 3 inches. The cards contained the main subject and specific sub-topics, the names of the booklets or exhibits, the branch of science they were most adapted for, and the name and address of the firm sending such material. The complete filing card looks like the following:

Communication.

Telephones and Telegraphs.

1. Magic of Communication.
2. Things Worth Knowing About the Telephone (pamphlet).
3. The 1927 Telephone Almanac.
4. The Birth and Babyhood of the Telephone.
5. Through Electrical Eyes.

(Elementary and General Science.)

American Telephone and Telegraph Co., 195 Broadway, New York City.

The material consists of booklets, pamphlets, charts, maps, and exhibits. These have been classified alphabetically under the following headings: Animals; Apparatus; Building; Clothing; Communication; Electricity; Food; Health; Industrial; Processes; Inventions, Light; Mechanical Devices; Plants; Rocks; Minerals and Metals; Safety Education; Time Telling; Transportation and Travel; Weather; and Miscellaneous. Each of these headings, of course, is divided into several sub-headings.

All of the classifications are simple and familiar; therefore it is very easy to locate material. If a teacher wishes material on the subject of telephone for instance she simply turns to the heading *Communication* and the sub-heading Telephones.

Some overlapping of material, of course, is bound to occur. Consequently, when material may be found under two headings cross-references are used. For instance, material on milk may be found under *Food*, Milk and also under *Health*, Milk. This system makes possible the quick and effective location of all available material on a subject.

After the materials were listed on the filing cards they were placed in the cabinet and arranged under the main headings of the cards. Large 12 by 8 inch boxes, three inches deep, were used to store the pamphlets. The exhibits were placed in order in a show case. The maps were tabulated with the main card heading and arranged in a drawer.

By this method knowledge and location of certain materials may be quickly obtained by glancing through the card files; securing of such materials may be had by referring to the corresponding sections of the cabinet. Although items from the above sources are useful teaching aids they by no means include all the helpful supplementary materials. Time will not permit me to treat in detail all the other sources but I might mention those which will bring this subject in a general way up to date.

The importance of supplementary reading has been indicated by a study made by Curtis.* Among the magazines which have been found useful to supplement the regular textbook are the following: *Popular Science Monthly, Popular Mechanics Magazine, Science and Invention, Scientific American, American Forests and Forest Life, Nature Magazine, Current Science*, and others.

Teachers with funds available for enlarging the library of popular books on science should consult the High School Science Library by H. A. Webb, published each year since 1924. Two sets of books dealing exclusively with science and which have been found helpful in the science work are Outlines of Science (4 volumes) and The Book of Popular Science (15 volumes). Both of these sets deserve special mention for reading in Junior and Senior High School Science.

A large number of government bulletins are available for

*Francis D. Curtis: Some Values Derived from Extensive Readings of General Science. Contribution to Education No. 163. New York: Teachers College.

references and may be had for the asking. *The Beaver Habits and Experiments in Beaver Culture by Vernon Bailey,* Technical Bulletin No. 21, is a good example of the splendid reference material which may be obtained free. Teachers should request the Department of Agriculture to send the list of new publications each month. Then it requires very little time to check the items desired and return the list. Gradually build up a library of bulletins which can be used in connection with certain units of your course.

(d) Pictures. In Cleveland pictures are now available through the Educational Museum under the direction of W. M. Gregory. These pictures are made up into sets for a specific unit of instruction. For example, if the unit should be domesticated animals the teacher may order from the Educational Museum the set of pictures prepared for this unit in the course of study. In other large cities visual materials are distributed to the schools in a similar way. Excellent pictures of animals may be had from the Bureau of Animal Industry, Washington, D. C. Still other splendid pictures for certain units may be obtained from the Grolier Society, New York.

(e) Exhibits and Models. The more costly exhibits and models are also available to our schools from the Educational Museum. We are not warranted in asking schools to make large expenditures for materials which are used for a few minutes and then placed in our store room until next year. From the museum the same exhibit may serve ten to fifteen schools during a semester. For example, the planetarium, models of eye, ear, reproduction of the frog, and others are distributed from our Educational Museum.

(f) Lantern Slides. Lantern slides are available from certain commercial firms, from the United States Government and from the supply houses. Certain firms as you know are arranging their slides into sets with specific directions for their use. In Cleveland the slides have been purchased from various sources and arranged in sets to meet the needs of definitely organized units in the courses of study. For example in the primary grades the robin is the title for one set. These slides tell the life story of a robin. They show the male, the female, the nest, the eggs, the young, the feeding and care of the young. With each set are essential facts about the topic for the teacher's use. Lantern slides are becoming a regular teaching device in many schools.

(g) Films. Another type of visual aid which should claim our

attention is the motion picture. These films offer wonderful opportunities for the learning of science as has been shown by the experiments conducted by Dr. Ben D. Wood and Dr. Frank N. Freeman for the Eastman Kodak Company. The 5,500 children taught with the aid of motion pictures showed a gain of 33 per cent in geography and 15 per cent gain in general science over the score of 5,500 children taught without the aid of films.

Even with this evidence in favor of the use of films there are still several problems confronting us before they can be extensively used as a teaching device.

First we need films made for specific units in our courses of study in the elementary, junior high, and senior high schools. There have been available for several years a more or less limited library of films from several sources, but these have been general in nature and by no means meet the present needs. As you know there is a growing tendency to develop special school films for science and other subjects.

Secondly we have the problem of cost which is an item we must consider. If schools cannot afford to buy a complete library they should be able to supplement their library or depend entirely upon a central main library. In Cleveland the films are purchased and placed in the Educational Museum. They are then distributed to the schools for a loan period as needed.

How long we may class some of these materials as supplementary instead of standard teaching aids remains to be seen, but whatever their classification they must be considered essential teaching helps.

It seems to me that our problem is to find the available materials, and classify them for use in connection with specific units. Then make the best use of them to vitalize our science courses and to relate the world about us to the experiences of the pupils.

NATIONAL SOCIETY OF COLLEGE TEACHERS OF EDUCATION.

CLEVELAND MEETING, FEB. 25-27, 1929.

Monday morning, General Topic: Fundamental Courses in Teacher Training.

Monday afternoon, Open meeting, Central Theme: Improvement of some Phases of Instruction and Administration in Colleges of Education.

Tuesday morning, Round Table Conferences.

Tuesday afternoon, Program for Open and Joint Session of the National Society of College Teachers of Education and the Educational Research Association.

Wednesday morning, Topic: The 1929 Yearbook.

MODERN METHODS AND INSTRUMENTS IN THE STUDY OF THE HEAVENS.

By Wm. T. Skilling,

Associate Professor of Astronomy, State Teachers' College, San Diego, Calif.

The last few years has witnessed a revival of popular interest in the subject of astronomy. Three reasons may be assigned for this. First, the invention of new scientific equipment for the observatory and the more extensive application of the principles of physics and chemistry to research in astronomy. Second, the wide publicity given discoveries in astronomy through the medium of magazines and newspapers. Third, the introduction of astronomy into practically all high school or junior high school courses as a part of the general science work.

Still there is much misapprehension as to the nature of an astronomer's work. He is pictured as a lonely watcher of the sky gazing all night through his telescope at the heavenly host. As a matter of fact very little visual work is done in the observatory. Photography has displaced direct observation.

The telescope has become chiefly a light gathering device for feeding radiation into such instruments as the camera, the spectrograph, the spectroheliograph, the radiometer, the thermocouple, the photo-electric cell, and the interferometer. The telescope alone is capable of giving some information as to the motions and distances of stars but none at all as to their composition, their temperatures, their size, or the physical condition of the gases of which they are made.

The use of other instruments makes the telescope none the less necessary. Without it they would be useless. The size of telescopes has been increasing, the largest now having an object glass of 100 inches in diameter. One of 200 inches is soon to be constructed.

Astronomers are often asked how powerful a certain telescope is. This is not a very intelligent question for the power of a telescope is exerted in two quite different directions. One may be a very powerful light gathering agent, another may magnify powerfully. The former quality makes for efficiency in bringing to view stars too dim to be seen with a small instrument, and the latter magnifies so as to separate close double stars, or bring out smaller details in the sun, moon and planets.

Illustrations of both of these qualities pushed to extreme are seen at the Mount Wilson observatory near Pasadena. The 100-

inch reflecting telescope photographs stars down to the twenty-first magnitude, and has revealed millions of stars beyond the power of any other instrument. The 150-foot tower telescope, on the other hand, has an object glass of but 12 inches in diameter, but on account of its great focal length it gives an image of the sun 17 inches across and shows sunspots in clear detail. It is unnecessary to have very great light gathering power in a telescope used, as this one is, for the sun only.

Like all "greatest things in the world" these two telescopes, each of which is unexcelled for efficiency in its own field, challenge our attention. The tower telescope is a new development in astronomy. Need was felt for greater magnification, and therefore for a larger telescope. Such a telescope together with its long, heavy spectroscopic attachment could not be supported at an angle without bending. First, a horizontal position was tried, the whole instrument lying along the ground. A coelostat placed at one end and driven by clockwork reflected the sunlight into the object glass. This was a convenient way of securing great focal length, but the air near the surface of the earth is heated by contact with the ground, and is therefore in a state of more or less turmoil causing an unsteady image.

By admitting the light into the upper end of a vertical telescope far above the ground, "seeing" is better, provided only that the tower can be kept from trembling in the mountain breezes. To remove the effect of wind the four corner posts and all their cross braces are enclosed in a second tower of hollow steel casing that does not touch the tower, actually supporting the optical parts of the telescope. The outer tower serves as a wind break and supports the dome covering the coelostat and lens at the top.

Since the lines in the spectrum of the sun are so important in solar study it is very necessary that the spectrum should be as long as possible. It is well known that an ordinary laboratory spectroscope will just separate the D lines of sodium. These are frequently spoken of as *the* sodium line, because in a small instrument they appear as one. The powerful spectrograph used in connection with the 150-foot tower telescope separates these lines 1.2 inches apart *and shows twenty-seven other lines between them.*

The grating used in making this spectrum is placed at the bottom of a well 75 feet deep under the telescope tower.

A seventeen inch image of the sun is produced in a laboratory at the surface of the ground, and light from any part of this

image may be allowed to pass through the slit and descend to the grating.

When this light returns again by reflection to the surface it is spread out into a magnificent spectrum, the total length of which from the first of the visible red to the last of the ultra violet is about 70 feet. With red sensitive plates it has been found possible to greatly lengthen this spectrum by photographing lines far into the infra red.

A generation ago Professor Rowland at Johns Hopkins University made diffraction gratings and charted the lines of the solar spectrum giving the wave length of each and telling what element produces it so far as he was able to identify the source.

Recently at the Mount Wilson Observatory Dr. St. John and his associates have revised and greatly extended the Rowland tables. With a telescope and spectroscope of increased power they have been able to add many lines not known before. The list now comprises 21,835 lines for the solar spectrum.

From a laboratory study of lines made by artificial sources of light containing known elements the source of many more of the solar lines is now known. Of the ninety known terrestrial elements fifty-seven ("fifty-seven varieties") have been identified in the sun and listed in St. John's tables.

In addition to the discovery of elements in the sun through a study of the lines a few *compounds* have been found in the cooler "spots." These manifest themselves in the so-called band spectra. Only such compounds are found as can withstand remarkably well the effects of heat. Even the sunspot temperature of 4000°C is sufficient to break down most compounds, or rather to prevent their formation.

Much attention is given to the study of sunspots. Whether or not any correlation will ever be made between them and our weather is doubtful. But they seem to have an effect upon terrestrial magnetism. The spots themselves are centers of magnetic force, caused doubtless by the circular whirl of ionized gas.

By employing the Doppler effect motions in the vicinity of the spot are studied. By letting the light from a spot pass through a Nicol prism it is found to be polarized, for the Nicol splits some of the lines into two, three, four, or more parts. One chromium line gives twenty-one components. Thus the sunspots are found to be powerful magnetic fields, and, by the spread of the lines, the field strength is measured.

Every day the image of the sun is projected upon a sheet of

cardboard and the spots sketched. Their light is then sent through the spectroscope as described above and their polarity determined and the strength of their magnetic field.

An accurate measurement of the amount of heat received from the sun by the earth has been a difficult problem to solve. Dr. Charles Abbot of the Smithsonian Institution led the way in this line of research. His pyrheliometer for measuring solar radiation is essentially a blackened metal plate of known weight and specific heat with which is connected a sensitive device for measuring its rise in temperature. Held in the sunshine its rise in temperature is noted and the number of calories received in a given time is calculated.

It is easy in this way to measure the amount of heat actually reaching the surface of the earth, but to find how much would have been received if none had been absorbed by the air is more difficult.

Two methods may be used to estimate the amount of heat absorbed by the air. One is to take readings with the pyrheliometer at sea level and at various elevations as high up as mountains can be climbed or balloons sent with instruments. The other, less arduous, is to take several readings at the same station at different times of day with the sun shining through different depths of atmosphere on account of the varying angle at which the rays fall.

From a long series of determinations made at laboratories in North America, South America and Africa, Abbot and his associates find that the so-called "solar constant" of heat reaching the earth is about 1.94 small calories per minute per square centimeter. This amount is the same winter and summer and in all latitudes. It differs about 5 per cent however, from time to time, due to changes in the sun itself.

As instruments of precision have been made more sensitive heat determinations have been extended to the stars. There are three instruments sensitive enough to register the heat of a single star. First, there is the radiometer operating upon the same principle as the whirling device of the same name often in jewelers' windows. Second, the bolometer, which depends upon changes in electrical resistance of metal when heated. Third, the thermocouple, which produces a current when heated at the junction of two metals.

In each of these cases an image of the star is made with a telescope of as large an object glass as possible, and this point of

light is allowed to fall upon the sensitive element of the radiometer, bolometer, or thermocouple. Enough heat is imparted to it to cause some deflection of an indicator.

Thus all the heat coming from a single star to the whole surface of the 100-inch reflector at Mount Wilson can be focused upon the tiny disk of the thermocouple, little larger than a period in print. Enough current is produced by the heat to cause a spot of light reflected from the galvanometer to move a considerable distance upon a screen.

The exceeding sensitivity of such instruments can be better appreciated when we consider that the amount of heat coming from the very bright star, Arcturus, is only equal to that which would be received from a candle six miles away.

Having determined experimentally, as above, the rate at which heat is radiated from a body it is easy to deduce its probable temperature. This computation rests upon the fact that bodies radiate heat in proportion to the fourth power of their temperature, provided they are perfect radiators. The sun and stars are assumed to be nearly equivalent to a so-called "black body" in their power to radiate heat and therefore to have about the temperature found by the use of the above formula.

In finding the temperature of such a body as the moon or a planet which *reflects* as well as *radiates* heat it is necessary to distinguish between radiation and reflection. To do this the rays are passed through a water cell. Dark heat, such as radiates from a cool body like planets, cannot pass through water so readily as that which originates in an incandescent body like the sun. Thus the dark heat that radiates from a planet on account of its own warmth can be separated from that which is merely reflected.

As a result of such measurements it is found that the rocky surface of the moon on its bright side becomes about hot enough to boil water, but that on its dark side the temperature goes far below zero. Mars, also, at the equator is only about as warm as Washington, D. C., in March.

Far back in the history of mankind astronomy was the first science to be developed. It has passed through the stages of crude apparatus and often crude reasoning. No science of today is equipped with more precise or powerful instruments than are now used by astronomers. And no science is more receptive to new theories such as those having to do with the structure of the atom or those of Einstein regarding relativity.

With all his scientific instruments and logical acumen the astronomer has even yet made only a beginning, for his field is the universe.

EXTRACTS FROM THE REPORT OF DEAN WILLIAM F. RUSSELL TO THE TRUSTEES OF TEACHERS COLLEGE.

One of the most perplexing of the problems confronting the American educational system arises from the simultaneous impact upon the school of three popular demands—that pupils be accommodated in greater numbers, that training of better quality be offered, and that there be greater economy in all public expenditures.

The American people want educational opportunities to be widely extended. Our nation was founded upon the assumption that all men are created free and equal and we have come to believe that all should have an equal chance. . . . The public school is dear to the hearts of the American people. Through it they hope to realize their fondest desires; and they will not rest content until every boy and every girl is given opportunity commensurate with ability, regardless of birth, wealth, or health. Americans want more education.

At the same time they want better quality of education. They are not satisfied with the schools as they are. Returning travelers receive thoughtful attention when they pronounce American education as inferior to European. Merchants and manufacturers complain of the deficiencies of the graduates of our schools. Famous critics perceive a lack of thoroughness, they detect a certain softness in our teaching; and they plead for the production of true scholars and a return to scholarly ideals. Legislatures enact laws requiring higher standards and better teachers. School authorities advance admission requirements and restrict attendance. Certain colleges practically elect to membership a favored few. Waiting lists are long. Institutions secure popular support by announcing as their aim education of fine quality, and they point with pride to small classes, individual instruction, and education by conference under a tutorial system.

The American people want quantity and quality, and at the same time display a solicitude concerning all public expenditures. The economy program of the national administration, which has had wide public appeal, has been reflected in states and localities by the appointment of budget directors, the adoption of economy policies, the rigid scrutiny of all payments, and the reduction of taxes. Some experts assert that the United States cannot afford to support its present educational program. This seems absurd, but one may well pause when he looks into the future. If the American people proceed with a policy of extending education widely and at the same time increase expenditures in order to work for quality, the time may be not far distant when we shall be forced to consider whether we, as a nation, can afford to pay for all that we want. It is to be hoped that our economists will address themselves to this problem.

. . .

The problem is as difficult as it is important. Those who favor quantity are extending educational facilities and welcoming the hordes of students who flock to the doors of our schools and colleges. Those who think first of quality are restricting attendance in order to do their best for small numbers. If it were possible to give a satisfactory education to large numbers in big institutions under conditions of reasonable economy, the results would be of utmost importance. After all, it is a question of the possibility of quantity production of quality in education.

THE WHEAT INDUSTRY—A CONTRACT IN HIGH SCHOOL COMMERCIAL GEOGRAPHY FOR TENTH GRADE.

By H. O. Lathrop,

State Teachers College, Whitewater, Wis.

"C" Level.

I. *Introduction: (Working Into the Problem.)*

Wheat is one of the basic foods of the world. It is produced in practically every country and is consumed in every civilized land. In some cases it moves half way around the world from the producer to the consumer. On the average, about 750,-000,000 bushels of wheat, or almost one-fourth of the crop, crosses the ocean or international land boundaries annually. If all of this crossed the ocean it would load 90,000 freighters of 5,000 gross tons capacity. Comparing it in another way, if all the wheat entering international commerce were loaded in box cars it would make a continuous train of cars reaching from New York to San Francisco.

Along the harbor front at Montreal are huge elevators for handling wheat. Large, endless belts carry the grain to the ships lying in the harbor. A finely developed organization makes it possible to load a boat from any of several elevators without the ship moving from its position. Montreal has spent enormous sums of money developing a harbor and loading devices for handling wheat efficiently. New York, Buenos Aires, Port Arthur, Canada, and many other ports over the world have similar facilities. From these ports hundreds of ships sail, carrying full cargoes of wheat. Thousands of men devote their full time and energies to the shipping, handling, and financing of the wheat commerce of the world. Millions of dollars of money are required to finance this commerce. Wheat commerce and the producing industry back of it constitute a major business of the world.

These facilities, this organization, these ships, these millions of dollars involved, emphasize in our minds the magnitude of the wheat industry, and raise the problem, "Why?" Why is the wheat commerce of the world so large, and why is it necessary? Why this vast organization of men and money to supply the world with wheat?

Other suggestive topics for preliminary discussion: 1. Bonanza Wheat Farming in the United States, Canada, and Australia. 2. The Problem of Wheat Supply During the World War. 3. Present Problems Facing the Wheat Farmer.

II. *General References:*

Whitbeck, Industrial Geography, 51-62; Smith, Commerce and Industry (Revised), 29-49; Brigham, Commercial Geography, 1-21; Ridgley, Economic Geography Notebook, 13-17.

III. *Finding the Answer to the Problem:*

A. In order to acquaint yourselves with the facts of wheat and the wheat industry, make a table from the map in Whitbeck, 562, or from the one in your classroom, showing wheat commerce. Make the table after the following plan:

Shipping Country	Waters Crossed	Destination
1. Argentina	across Atlantic	to English Channel Region
2		
3.		
4.		
5.		
6.		

Continue in this way until all the chief routes are listed. Write the complete table on a sheet of paper and hand in. Then write on the map on page 15 of your Notebook the important ports. Write on the map the names of the countries from which the wheat is shipped and to which it is sent. Color the map, page 15 of your Notebook, as directed on page 14. Read Whitbeck, 52-53; and study Figures 20 and 21; Brigham, 15-19. Now read a description of the wheat commerce of the world as given in Smith (Revised) 44-48; Whitbeck, 62; Brigham, 19-21.

B. What are the conditions that favor wheat production in these exporting countries?

1. Soil and Topography. What kind of soil and topography are best suited to wheat production? See Whitbeck, 53-54; Brigham, 3-4. Show fully how soil and topography are important factors in wheat production. Does it appear that the leading wheat producing countries have favorable soil and topography and the small wheat producers unfavorable soil and topography?

2. What factors of climate are favorable and what ones are unfavorable for wheat production? In answering this question note: (a) the amount, kind, and distribution of precipitation; (b) length of the growing season; (c) snow cover; (d) alternate freezing and thawing; (e) severity of the winters; (f) heat and humidity of the summers; (g) the location of the wheat areas to the semi-arid lands. Read Smith (Revised), 30-36; Whitbeck, 53; Brigham, 3-5; consult the rainfall maps, pages 8-10, of your Notebook, and 8-9 in Smith. Consider each of the leading wheat

producing countries in the light of these seven points. Which ones are poorly qualified? Point out several regions that produce little wheat because of one or more unfavorable climatic conditions.

3. What population densities favor wheat production? Consult the population map, page 6 of your Notebook, or the wall map in the geography room, and compare population densities of the leading importing and exporting countries. Describe fully the population conditions that seem most favorable and those that are unfavorable to wheat production. Read Smith (Revised), 41-44; Brigham, 5-6. Why do densely populated regions generally import wheat?

4. Why has extensive farm machinery been developed for wheat production? Describe the kinds of machinery used in the various operations, the extent to which it is used in the various countries, and its effect upon wheat production. What is the relation of this to Number 3 above? Read Smith (Revised), 36-40; Whitbeck, 57-60; Brigham, 6-8.

5. How does the transportation problem affect wheat production? How does the weight and bulk of wheat compared to value affect the transportation of wheat? In so far as possible describe the transportation methods used in each of the important wheat producing countries. In what ones is transportation difficult because of distance from the ocean? What ones are favorably located in this respect? Brigham, 21; Whitbeck, 56-57.

6. How are wheat production of the world and wheat commerce affected by the varieties of wheat grown in the various countries? Make a list of the chief varieties of wheat. What are some of the good qualities of each? What special uses have each? Where is each grown extensively and why? What ones enter into commerce in an important way? Read Brigham, 2-3; Whitbeck, 54-55.

7. Summarize in clear and concise sentences what you think are the important factors causing the extensive world commerce in wheat. Write these in your Notebook after discussion in class.

IV. *The United States in Detail:*

Before the World War the United States ranked second in wheat production, being surpas ed by Russia. For a decade the United States has led the world. Because the wheat industry is so important in our own country, it seems desirable that we should have a more detailed knowledge of the industry of the United States. Our second problem, therefore, becomes: Why

is the wheat industry so important in the United States, and how is it carried on? What difficulties and problems does the industry face?

1. In your Notebook color as directed the maps on page 16. What is the difference in the kind of wheat grown in the two areas? Why is each produced where it is? Which belt extends into Canada? How do methods of production there compare with those in the United States?

2. Give as many reasons as you can why wheat is produced extensively in the regions which you colored on page 16. In like manner list as many reasons as you can why each of the following regions produces little wheat: (a) Southern United States; (b) New England; (c) Nevada. See Figure 2 in Brigham to emphasize the unimportance of wheat production in these regions. From a study of Figure 30 in Whitbeck, where do you think there is an important commerce in wheat in the United States? Do you suppose any passes through the Panama Canal? Give reasons for your answer.

3. Describe the methods of wheat production in the Columbia Plateau; Wisconsin; Red River Valley of the North; Appalachian Uplands. Explain as fully as you can why different methods are used in the several areas. Figures: 1, 5, 6, 7, in Brigham; 26, 27, 28, 29, in Whitbeck; 20, 21, 22, in Smith (Revised), are suggestive.

4. Study Figure 25 in the latest edition of Smith. Why is wheat so widely grown throughout the United States? How does the wheat area of the United States compare with that of other countries? Does this help you to understand why the United States is the world's leading wheat producer?

5. Figure 22 in Whitbeck shows the yield per acre in the United States compared to other countries. Explain. Is our large production due to high per acre yield?

6. The per capita consumption of wheat in the United States is high compared to most other countries. Why is this true? How does it help to explain our large production? From a study of Figure 8 in the revised edition of Smith, do you conclude that most of the wheat of the United States is grown for domestic consumption or for export? Explain why Canada and Argentina export a l rger proportion of their crop than the United States does.

7. What pests and diseases attack wheat in the United States? How does each work and what remedies have been found for

each? In what part of the United States does each affect production in an important way?

8. Where are the leading flour milling centers of the United States located? Why there? Read: Whitbeck, 60-61; Brigham, 9-10; Smith (Revised), 46-47.

9. Summarize as many reasons as you can for the importance of the wheat industry in the United States. After discussion in class, write them in your Notebook.

V. *Supplementary Problems and Exercises:*

1. Why does wheat production in the United States vary widely from year to year, as shown in Figure 10, Brigham; and Figure 25, Whitbeck?

2. Why are grain elevator storage bins in a number of small units as shown in Figure 29 in Whitbeck?

3. Why is the per acre wheat yield of the United States low as compared to many other countries?

4. Why has the center of wheat production in the United States moved gradually westward? See Figure 4, Brigham.

5. What is the "wheat pit" in Chicago? What is its value? See Brigham, Figure 11.

6. Why has Minneapolis become the greatest flour milling city in the world?

7. What factors have made Winnipeg the greatest primary wheat market in the world?

8. Why are the spring wheat areas located to poleward of the winter wheat areas?

9. If the American farmer increases his wheat yield two bushels per acre, how much does he increase the total production of the country?

"B" Level.

When you have completed satisfactorily the work on the "C" level, start work on this part of the Contract. You cannot receive a "B" unless you work out this part of the Contract.

A. Read: Crissey, The Story of Foods, 36-59. Study the reference carefully, and be able to answer such questions as the following:

1. What does the calendar of the World's wheat harvest, pages 37-38, show?

2. Why is wheat so universally used?

3. How has wheat culture influenced civilization?

4. Explain the differences in methods of wheat production shown in the pictures on pages 41, 42, 43, 44, 47, 49, 52.

5. Make a list of as many wheat products as you can. Write your list in your Notebook and show it to your teacher.

6. What inventions have been important in the development of flour milling? Pages 53-59.

B. In a similar way read pages 77-84 in the 1921 Yearbook, Department of Agriculture, and study the figures carefully until you can explain what each one shows. There is an error in Figure 6, page 84. What is it?

"A" Level.

If you want an "A" on this Contract, read one or more of the articles listed below and hand in a written outline of each. You may be asked to give a five-minute report to the class on each topic read. You may use your outline for this report. The number of points of credit given for perfect work is indicated after each article. Not to exceed 20 points of credit may be obtained on the "A" level.

1. Stakman, E. C., Black Stem Rust of Wheat and How Barberry Spreads It. Pamphlet by American Steel & Wire Co. Pages 56-62. (10 points)

2. The Story of Bread. Pamphlet by International Harvester Company. (10 points)

3. Durand, L., The Grain Trade of the Great Lakes Journal of Geog. Vol. 24, Pages 260-267. (10 points)

4. Holman, C. W., Helping the Wheat Farmer Come Back. Review of Reviews, Vol. 69, Pages 286-290. (10 points)

5. Jewett, Problems of the Wheat Industry and a Way Out. American Industries, Vol. 24, Nov. 1923, Pages 5-9. (7 points)

6. The Chicago Wheat Exchange. See pamphlets in classroom. (Credit determined by number and character of pamphlets read)

7. Taylor, A. E., Wheat and Wheat Flour. Annals of the American Academy of Political and Social Science, Vol. 127, September, 1926. Pages 30-48. (20 points)

8. Hunter, Byron, Methods and Practices of Growing Wheat in the Columbia and Snake River Basins. Farmer's Bulletin, No. 1545. Pages 1-22. (15 points)

When you have finished the Contract, you will be given a examination covering the "C" and "B" levels. Your standing on the "A" level will be determined by the number and quality of topics studied and reported upon. The examination will be thorough, and you can make a high score on it only by reading all the references given; following carefully the instructions

given in the Contract; doing the map work required; and handing in the written work as directed.

"C" LEVEL.

True—False.

1. Wheat cannot be grown in Siberia because of the severe climate.
2. Wheat is grown chiefly as a supply crop in Canada.
3. In regions favorable to both winter and spring wheat, spring wheat is usually grown.
4. The United States can supply its needs for wheat without importing.
5. Wheat grows well in very hot and humid regions.
6. Wheat matures best in bright and comparatively dry weather.
7. A heavy blanket of snow is favorable to a good crop of winter wheat.
8. The yield of wheat per acre is increasing in the United States.
9. The yield of wheat per acre in Europe is usually less than in the United States.
10. The per acre yield of wheat in the United States varies considerably from year to year.
11. The Danube River is used to a great extent for wheat commerce.
12. Durum wheat is produced extensively in the Red River Valley of the North.
13. At the present time, the United States ranks first in wheat production.
14. The methods of production are the same in all areas of the world.
15. Since colonial times the United States has always been an exporter of wheat.
16. The large wheat production of the United States is due to the high yield per acre.
17. Canada and Argentina export a larger proportion of their wheat crop than the United States does.
18. The center of wheat production has remained the same throughout the history of the United States.
19. An important commerce in wheat is carried on over the Great Lakes.
20. The United States consumes more wheat per capita than any other country in the world.
21. Argentina will become more and more important for wheat production because of favorable location to ocean commerce.
22. Most of the wheat crop of the United States is consumed annually within the country.
23. A late spring does not affect the amount of wheat produced in a given year in the United States.
24. Good transportation has made wheat production profitable in India.
25. The per capita consumption of wheat is increasing in the United States.
26. The United States exports only a small percentage of the wheat produced.
27. A good season in other countries does not affect the price of wheat in the United States.
28. Winter wheat is the dominant crop in the Wisconsin region.
29. The price of wheat in this country is determined at Chicago.
30. The wheat production of Canada is gradually declining.

MULTIPLE CHOICE.

Place the figure indicating the correct fact in the blank at the left.

......31. The greatest wheat market in the world is: (1) Winnipeg; (2) Minneapolis; (3) Budapest.

......32. The chief surplus producing nation besides the United States is: (1) Australia; (2) Egypt; (3) Russia.

......33. The most important insect menace to wheat is: (1) chinch bug; (2) grasshopper; (3) Hessian Fly.

......34. Most of the wheat shipped from the Lake Superior region passes through: (1) Superior; (2) Port Arthur; (3) Duluth.

.....35. Losses from stem and root diseases are caused most by: (1) scab; (2) bunt; (3) stem rust.
.....36. Milling centers are generally located in: (1) areas where there is water power; (2) cheap fuel; (3) areas convenient to wheat supply and region of consumption.
.....37. Europe has a higher yield per acre than the United States because: (1) better varieties of wheat are grown; (2) more intensive farming is practiced; (3) better kinds of wheat are used in planting.
.....38. The most important wheat port on the St. Lawrence is (1) Quebec; (2) Montreal; (3) Halifax.
.....39. More wheat is carried through the: (1) Suez Canal; (2) Panama Canal; (3) Sault Ste. Marie Canal.
.....40. The United States exports most of its wheat to: (1) United Kingdom; (2) France; (3) Germany.

RECALL.

41-43. Three climatic requirements of spring wheat are:
44-48. Name six countries that rank high in wheat production.

1.	3.	5.
2.	4.	6.

49-50. Two important wheat producing areas in the United States are:
1.
2.

51-54. Give four ocean routes over which wheat moves in large quantities.

1.	3.
2.	4.

55-57. Southern United States produces little wheat because:
1.
2.
3.

58. What disease affects wheat most?
....
59. What type of soil is best suited to wheat production?
....
60. What is the leading wheat importing port of Great Britain?
....

"B" LEVEL.

61. Wheat is harvested somewhere in the world every month of the year
62. Wheat is grown only in the temperate zones.
63. Wheat was first discovered about 100 B. C.
64. Camels are used to draw modern harvesting machines in Siberia.
65. Wherever wheat is grown, modern machinery is used.
66. The average yield of wheat per acre in Britain is double that of the United States.
67. Wheat is produced in every continent.
68. Wheat is grown within six hundred miles of the Arctic Circle and within the torrid zone.
69. About 2,000,000 farmers of the United States grow wheat.
70. Wheat ranks first among agricultural exports in the foreign commerce of the United States.
71. In the last 50 years the wheat production in the United States has trebled.
72. The rapid rise in acreage and production in the United States beginning in 1915, was due to the World War.
73. What is the error in Figure 6, on page 84, of the 1921 Yearbook?
74-77. Give four reasons why wheat is an important crop in the United States, as listed in the 1921 Yearbook of the Department of Agriculture.
78-80. What three crops generally exceed the wheat crop in value in the United States?

THE SMALLEST THING IN THE WORLD.*

By C. E. Ronneberg,

Department of Chemistry, Crane Junior College, Chicago.

The modern economist tells us that one of the principal reasons for the great progress of our civilization the past one hundred years has been due to the increased use and the cheapening of various forms of power. Furthermore, the great contrast between our civilization and the civilizations of the East is due to the development of cheap and abundant power. In China today the water needed for irrigation is still laboriously and inefficiently brought up the hillsides from the rivers by man power. Goods are transported from place to place by men pushing large wheel barrows. It is said that in this country modern forms of power can transport a ton of goods cheaper a distance of a hundred miles by rail than you can get it carried ten miles in China. This power is based of course upon great forms of natural energy of which electricity is becoming daily more important.

But what is electricity? For a long time the true nature of electricity was unknown. In the time of Franklin, electricity was associated with lightning, of which mankind stood in deadly fear, something that flashed out of the sky to cause great material damage and even death. Perhaps the greatest triumph of modern physics has been in delving into the mysteries of electricity. Scientists now know that most of the phenomena that we call electrical are due to the smallest objects of the world, the electron, objects so very, very small that you may well wonder about the proof that we have for their existence.

An electron is a minute, discrete particle of negative electricity having a definite weight and charge. They exist in all forms of matter, for matter and electricity are now known to be in reality one substance. Here is a simple experiment that you might like to perform. Suspend two toy balloons by means of cords about two feet long at about the level of the face in the center of a room. Hang the balloons about a foot apart. Wrap a fur or a woolen sweater around one of the balloons so as not to touch it with the hands and rub briskly; take apart and hold the fur near the balloon. You should now find that there is an attraction between the fur and the balloon, so that the balloon follows the fur. In common parlance, we say that the balloon and fur are electrified.

*A twelve minute radio talk given over Station WORD, Chicago.

Rub the balloon again and hold your nose near the balloon. The balloon will suddenly move toward your face and upon meeting it you will feel and hear the discharge of a small electrical spark. Rub both balloons briskly and you will see the balloons fly apart, apparently trying to get as far away from each other as possible. Hold the hand in between the balloons and they will immediately come together.

These simple experiments will serve to emphasize the fact that matter and electricity are intimately associated, and by the simple process of friction we have succeeded in putting these bodies in a state of electrification. Frictional electricity is often responsible for disastrous fires. For instance, a common cause of fires at gasoline filling stations is the ignition of gasoline vapor while filling cars by electric sparks from electricity caused by the passage of gasoline through the rubber filling hose.

Scientists have amply proved that matter in all its forms is electrical in its ultimate nature. There is enough electricity in an old tin can to light your home and run your radio set if you could only get it free and collect it. We collect, not make electricity, since it already exists and is present in everything. Electricity is made up of countless particles of two kinds, positive and negative. The positive charges are referred to as protons, while the negative particles are the electrons to which I have already referred. The positive charges are relatively immobile, but the electrons move about easily. When by any process an object obtains an accumulation of electrons, that is, more than its normal supply, it is said to be negatively charged. Vice-versa an object that loses electrons becomes positively charged, since the stationary positive charges remain. Thus when the balloon is rubbed with a fur, the electrons leave the fur and accumulate on the balloon, which is then negatively charged. The fur which loses electrons is positively charged and the two attract each other. When the two balloons possessed the same charge they repelled each other.

These electrons are unbelievably small, and represent, in fact, the smallest objects in the world. They are so very small that twelve million million of them would have to be laid side by side to make an inch. In spite of their very minute size, there are few objects in science whose weight and size are more accurately known. As a matter of fact, the methods used to obtain the weight of the electron were extraordinarily accurate, so much so that the method that your neighborhood grocer uses

to weigh out a pound of butter is exceedingly crude in comparison.

These electrons are in everything. A drop of water, for instance, is made up of millions of tiny particles called molecules. If we could examine a single molecule of water, we would see that it is made up of two tiny specks, or atoms of hydrogen, and one tiny speck, or atom of oxygen. But the scientist has carried the process of subdivision even further and has been able to show that each hydrogen atom is made up of one positive charge or proton, and one electron. The atom of oxygen is somewhat more complicated, being composed of a center portion or nucleus consisting of sixteen protons with eight electrons, and revolving about this nucleus are six more electrons in continual motion, circling around the nucleus much in the same way as some bees might circle around a flower.

This small particle of hydrogen represents Nature's simplest substance, being composed of one proton and one electron. If the orbit of a single hydrogen atom were magnified to the size of the earth, the positive charge at the center would have a diameter of about five inches, and the diameter of the electron at the equator would be about eight hundred feet. In other words, the electron would be rotating at a distance of four thousand miles from the proton in the center. The electron revolves about the nucleus at a velocity of about 1400 miles per second and makes about 7,000,000,000 revolutions in one billionth of a second. Strange to say the electron though nearly 2000 times larger as far as size is concerned than the proton, actually weighs only about 1/1800 as much as the proton. In other words, the weight of the atom is due almost entirely to the proton.

It is hard for us to believe that all forms of matter are in reality for the most part empty space. The weight of the earth is quite accurately known, likewise the weight and size of the proton. Hence it is a simple calculation to find out what the entire volume of the earth would be if the vast space between the protons and the electrons could be eliminated. This volume turns out to be a ball about twelve inches in diameter. Thus the entire earth, if it were possible to eliminate all intervening spaces between protons and electrons, might be packed in a moderate sized hand-bag. So we, as individuals, are no more than of microscopic dimensions. Perhaps now the famous lines of the poet, "Oh,why should the spirit of mortal be proud?" will take on a new significance.

It is interesting to note some of the methods used to collect these electrons and to make them work for us. One of the simplest ways is by chemical action. The next time one of your B batteries goes dead, tear it apart and examine it, and you will find that the zinc container of each little cell has corroded away. You will also notice that the interior of the cell is moist, due to a solution of ammonium chloride or sal ammoniac. If the interior of the cell were truly dry, the cell would not work. As the zinc corrodes and disappears in the sal ammoniac some of the electrons associated with the zinc are set free and stream into your set over the wire connections, constituting an ordinary electric current. So your B battery, or any other battery for that matter, is a sort of electron pump.

A second important way to set free electrons is to heat a metal to a high temperature, a dull red for instance, when it spontaneously emits large numbers of electrons. The function of the filament in your radio tubes is to shoot off millions of electrons when heated to a dull red, for without these electrons your radio tubes cannot function.

Possibly the most important way of collecting electrons is by means of the electrical generator or dynamo. Billions upon billions are collected by these machines at our central power stations and sent on their way over wires into our homes, shops, and factories.

An electrical current, then, is a continuous stream of electrons, moving in a wire or conductor, much as water moves in a pipe. When you turn on an ordinary forty watt lamp about 2300 quadrillion electrons pass through the filament each second. It would take 5,000,000 people counting at the rate of three per second, about 5,000 years to count this number.

It is these electrons streaming off the heated filaments in radio tubes that make it possible to talk through the air. A high frequency, or oscillating current, is needed for broadcasting, and this current is produced in a tube similar in construction to an ordinary radio tube. In your radio set, one of the tubes acts as a detector, while the remaining tubes are probably amplifying tubes. But whether a tube functions as an oscillator, detector, or amplifier, it is the electrons that stream off the heated filament that enable the tube to function the way it does. If the filament assumes a condition in which it can no longer emit electrons, the tube ceases to work. Sometimes by the simple process of lighting the tube for a short time at a

voltage higher than its customary voltage will enable the tube to function again. Apparently the higher temperature and higher voltage succeed in driving more electrons to the surface so that they can be emitted. This process is known as reactivation.

The current used in your home is probably alternating current, which means that the electrons are rushing back and forth 120 times per second. Obviously it would be impossible to charge your A battery if these electrons were simply pumped in and then allowed to come right out again. So you use a charger of some kind, the purpose of which is to sort out electrons going only one way so that when they stream into the battery they remain there. In this way the cell finally becomes charged. Thus the cell acts as a storehouse of electrons, delivering them to your set as they are needed.

The modern X-Ray is another marvelous effect of electrons. When a stream of electrons moving at a high speed strikes a metallic surface in a vacuum, X-Rays are produced which can penetrate forms of matter that ordinary light cannot penetrate. So by means of the X-Ray the medical man can locate and study diseased areas deep in the flesh, can study bone fractures, or locate hidden foreign objects in the body. The X-Ray also enables the scientist to find out the actual arrangement of the protons and electrons in various forms of matter.

In conclusion, let me emphasize the great debt that mankind owes to the scientists who have been responsible for the exact knowledge that we have about the electron. They have been silent workers in silent places. Without all the information that we have concerning the electron, much that goes to make life so pleasant to-day would not exist. The radio is but one example of a device among many that might be mentioned that we would not be enjoying to-day, but for the pioneer work of the scientists in studying the electron, the smallest thing in the world.

A JOLT THAT CAN KILL A GERM.

Recently Dr. F. Holweck, noted French X-Ray expert, applied the destroying power of the rays to calculate exactly how much it takes to kill a single disease germ. Imagine, if you can, the force of the blow struck by the smallest visible speck of dust after falling a distance equal to the thickness of this paper. Then divide this force by a million, and you will have the jolt that can kill a germ.—Louis A. Wendelstein, at the November Meeting of Eastern Association of Physics Teachers.

THE STATUS OF THE SCIENCES AS ENTRANCE SUBJECTS IN THE COLLEGES OF LIBERAL ARTS.

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This investigation was undertaken to determine the extent to which the different sciences are accepted and required as entrance subjects in the Liberal Arts colleges; to find indications regarding the relation of science subjects to other subjects; to note how these practices vary for the different sections of the country; and to discover any tendencies and changes which may be occuring in these practices.

For the purpose of making comparisons for different parts of the nation, the 48 states, District of Columbia and Hawaii have been divided into the following regions: North Central, New England, Middle States and Maryland, Southern and Western. The first four of these regions correspond to the groups of states included in the Associations of Colleges and Secondary Schools which go by these regional names. Therefore in later references to regions it is meant that the North Central region includes all the schools studied which are in the 15 states from which the North Central Association of Colleges and Secondary schools draws its members, regardless of whether or not the individual schools are members of this association. The same holds true for the schools in the 6 states of the New England region; in the 5 states and the District of Columbia of the Middle States and Maryland region; in the 14 states of the Southern region; and the remaining 8 states and Hawaii have been termed the Western region though there is no such association.

Table I. Distribution of Schools by Regions.

Region	Number in region	Number studied	Percent of total studied
New England	34	20	58.8
Middle St. & Md.	109	44	40.4
North Central	205	113	55.1
Southern	164	91	55.5
Western	40	22	55.0
Nation	552	290	52.5

Science as a Required Subject.

Table II shows that out of the 290 schools studied, 55 percent of these require some science as part of their entrance subjects.

[1]This paper was prepared in collaboration with Professor S. R. Powers, Teachers College, Columbia University.

TABLE II. THE PERCENTAGE OF SCHOOLS REQUIRING SCIENCE FOR ENTRANCE COMPARED WITH THE PERCENTAGES FOR OTHER SUBJECTS.

Region	Science	English	History Civics	Languages	Mathematics
New England	30.0	100.0	80.0	100.0	100.0
Middle St.	34.1	100.0	66.6	82.9	97.1
North Central	69.0*	100.0	75.0	60.0*	98.5
Southern	40.6	100.0	80.5	75.9	98.7
Western	81.8*	100.0	83.3	72.2*	100.0
Nation	55.0	100.0	76.6	72.1	98.0
Rank	5	1	3	4	2

*Exceptions to general ranking.

The schools by regions differ very much in this respect. Only 30 percent of the schools in the east require science for entrance. The requirement is heavier the further west one goes—the Western region stipulating science in 81.8 percent of its schools. In addition to these schools, there are two others which state that if no laboratory science is offered for entrance, the student must take one while in college—however, getting full college credit for it.

Table II shows that for the nation the order of required subjects is English, mathematics, history and civics, languages and lastly science. However, in the North Central and Western regions science ranks ahead of languages as a prescribed subject. Only in the east do languages rank ahead of history and civics, the former being in third place. The ranking in Table II is in agreement with what Furst (4) found in 1924. Concerning this he stated that there had been no recent change in the relative importance of subjects. The order was at that time the same as now.

The following states ranked highest in science requirement:

North Central

Indiana	9 out of 9 studied	
Michigan	10 out of 10 studied	
Wisconsin	5 out of 5 studied	
Colorado	5 out of 5 studied	
Kansas	7 out of 9 studied	

Western

California	6 out of 7 studied
Idaho	3 out of 3 studied
Oregon	4 out of 4 studied

Southern

West Va.	2 out of 2 studied
Missouri	6 out of 9 studied
Tennessee	4 out of 8 studied
Kentucky	3 out of 5 studied
S. Carolina	5 out of 10 studied

Eastern States

The individual states of New England and the Middle States and Maryland were all uniformly low.

There is a noticeable though slight tendency to increase by one unit the total number of required units for entrance when science is prescribed, thereby permitting one less elective to be offered. In many states and schools this tendency was not evident.

TABLE III. THE NUMBER OF STATE UNIVERSITIES REQUIRING SCIENCE FOR ENTRANCE.

Region	Number of States	Number of Universities included	Number Requiring Science	Percentage Requiring Science	Percentage for all schools
New England	6	3	1	33.3 +	30.0
Middle St.	5	4	2	50.0 +	34.1
N. Central	15	15	8	53.3 –	69.0
Southern	14	12	3	25.0 –	40.6
Western	8	8	6	75.0 –	81.8
Nation	48	42	20	47.6 –	55.0

Table III shows that the state universities do not require science for entrance in relatively as many cases as the colleges in general do. The former require it in 47.6 percent of the schools and the latter in 55.0 percent. The general frequency of this requirement by regions is in the same order for the universities as for the schools as a whole with the exception of the Middle States. In this region the state universities have a higher percentage with a science requirement.

There were *13 schools* or 9 percent of those requiring science which stipulate *two units of science for entrance.*

These are distributed as follows:

Colorado	4 out of the	5 which require science
Ohio	1 out of the	11 which require science
Minnesota	1 out of the	7 which require science
Idaho	3 out of the	3 which require science (all the schools)
Tennessee	2 out of the	4 which require science
S. Carolina	2 out of the	5 which require science

CHANGES IN SCIENCE ENTRANCE REQUIREMENTS FROM 1921 TO 1927.

A comparison of the number of schools stipulating science for entrance in 1921 (1) with those doing so in 1927 as shown in Table III brings out that 13 schools which did not require science in 1921 are requiring it in 1927. Two other schools increased their requirements from one to two units. During this same period 27

schools removed their science requirement and four reduced it from two units to one unit.

TABLE IV. THE NUMBER OF SCHOOLS WHICH CHANGED THEIR SCIENCE ENTRANCE REQUIREMENTS BETWEEN 1922 AND 1927.

Region	Increasing from		Decreasing from	
	0 to 1	1 to 2	1 to 0	2 to 0
New England	0	0	2	1
Middle St.	2	0	3	0
North Central	3	1	17	1
Southern	6	0	5	2
Western	1	1	0	0
Nation	13	2	27	4

As is indicated in Table IV, the changes about balance each other except in the North Central region where 17 schools removed their science requirement entirely and only 3 added it during these last five years. There are therefore 14 schools less requiring science in 1927 than in 1922. The change for the whole nation shows a decrease from about 60 percent for 1922 to 55.0 percent for 1927.

A study was made of the changes in other subject requirements for the 46 schools which showed changes in their science requirements. Of these schools six decreased the number of English units from four to three while only one school increased it. In history nine schools increased and the same number decreased the number of units required. In mathematics ten schools decreased their requirements while only one increased it. In languages twelve lowered the number of units while four increased it. In only a few instances were the requirements entirely removed for a given subject. Instead the majority retained their requirements by subjects and only changed the total number of units in the individual subjects.

The change noted in science as well in the other subject fields, although slight, is nevertheless an indication of a larger change which has been going on in recent years, namely, a decrease in the number of prescribed subjects and units for college entrance. Furst states, "The total number of units (for all subjects)[2] prescribed, decreased from 2025 to 1268, from 72 percent to 44 percent, between 1912 and 1920—a decrease of 37 percent. (2)." Furst states further, "As colleges grew more liberal in requirements, their matriculants offered an increasing excess of work over the requirements in the traditional subjects, took little

[2]Writer's insertion.

advantage of the opportunity to present vocational subjects."

One should not conclude from the above figures that science is becoming less desirable as an entrance subject, but rather, that it, along with other subjects, is not being stipulated as frequently as formerly as one of the prescribed units. Possibly science is being offered as an entrance subject just as frequently as formerly. A study by Furst (4) of 30,864 cases showed that the average matriculant's entrance subjects included 4 units of Latin, 3 of English, 3 of Mathematics, 2 of French and History and 1 each of Physics and Chemistry. Science is definitely being accepted more than it used to be as is brought out by comparisons with previous years even though it is not prescribed as frequently as formerly.

A few schools state alternate subjects which may be offered for entrance. This occurs most frequently within the individual subject groups, as for example, where Greek or Latin, French or German, chemistry or physics may be presented. In addition to this though, five schools make the requirements still more flexible by stating that either languages or science may be presented and one school states that either mathematics, languages or science should be offered.

Listed Science Subjects Acceptable as Entrance Units.

Out of the 290 schools studied, 209 stated which sciences would be accepted as part of the usual 15 units required for entrance. Table V shows this range by subjects and regions.

Table V. The Number of Schools Accepting the Separate Sciences as Entrance Units.

Region	Number of Schools	No. Schools with lists	Chemistry	Physics	Biology	Botany	Zoology	General Science	Physiology	Phys. Geog.	Com. Geog.	Astronomy	Geology	Agriculture
N. England	20	19	19	19	15	14	10	3	4	11	1	1	1	0
Mid. Sts	44	33	33	33	27	24	22	8	12	21	3	5	5	3
N. Cent	113	72	72	71	29	65	63	40	57	48	4	20	27	10
Southern	91	73	72	72	40	67	61	42	57	56	6	2	11	21
Western	22	12	12	11	8	10	10	7	8	8	0	0	1	4
Nation	290	209	208	206	119	180	166	100	138	144	14	28	45	36

Table V shows that chemistry and physics are almost always accepted as entrance subjects. Botany is third in rank with 86 percent of the schools mentioning it. Zoology comes close but

there are a few schools which will not accept it where they do accept Botany. Physical geography is fifth with 69 percent. If Commercial geography were included with it, Physical geography would rank close to zoology. Physiology, under which are included a few cases of hygiene and sanitation, is sixth being accepted in 66 percent of the schools. Biology is seventh for the whole country though it ranks third in the Middle States and New England. In these same regions zoology is placed sixth instead of third as it is for the nation.

General science is eighth for the nation. As an entrance subject, 48 percent state that they accept it. The Middle States and New England rank very low with 24 and 16 percent respectively.

Some schools, particularly in the North Central region, are admitting students with three years of high school work beyond the Junior High School level. When this is the case, it may possibly operate to increase the frequency with which General Science is accepted as this subject usually comes in the ninth year of the Junior High School. However, no statement to this effect was found in any of the catalogs.

Geology and astronomy were acceptable in only 21 and 13 percent of the schools. Both rank highest in the North Central region. They are not even mentioned in the Western schools.

Agriculture was mentioned most frequently in the Southern and Western regions. It, however, was not always included among the science subjects, although the school possibly accepted it as a vocational subject. Therefore, the figures in Table IV do not indicate correctly the extent to which this subject is acceptable.

The ranking seems to have a relation to the amount of laboratory work required in the given sciences, and to the prevalence with which the subjects are taught in the secondary schools of the respective regions. In the East in particular there were a number of schools mentioning only those sciences which are included by the College Entrance Examination Board. These will be mentioned later.

Table IV is based upon the sciences actually mentioned as being acceptable in the individual schools. Therefore, the figures and summaries must represent the minimum number of schools accepting each science as it is quite probable that in many instances many of the less common subjects for the region or state have simply been omitted because it is seldom offered as an entrance unit.

Subjects to Which some Schools Definitely Restricted their Required Unit.

Twenty-eight schools limited the choice of their required science subject, permitting the other science subjects which they listed to be included among the electives. This choice or limitation is shown in Table VI.

Table VI. Science Subjects to Which the Required Science Unit was Limited.

Region	Chemistry	Physics	Biology	Botany	Zoology	Physiology	Gen. Science	Phys. Geog.	Agriculture
Eastern	3	3	1	....	....	....	....	....	....
N. Central	14	14	3	9	9	....	2	1	1
Southern	6	5	3	3	3	2	1	....	....
Western	5	4	3	4	4	2	....	1	....
Nation	28	26	10	16	16	4	3	2	1

One school states that the required science must be one that is given in the third or fourth year of high school. Two schools state that General Science may *not* be included with the required sciences.

Maximum Science Units Allowed for Entrance.

Forty-two schools definitely stated the maximum number of units of science subjects which could be included among the usual 15 units of all subjects required for entrance.

The maximum in 4 schools was 2 units of science
The maximum in 12 schools was 3 units of science
The maximum in 17 schools was 4 units of science
The maximum in 7 schools was 4 ½ units of science
The maximum in 1 schools was 5 units of science
The maximum in 2 schools was 6 units of science

(Rollins, Fla.) (U. of Mississippi)

Iowa had 6 schools, all of which had 4 ½ units as the maximum. Of the above 42 schools, 21 are in the Northern region; 11 in the Southern region; 6 in the Middle States and Maryland; 2 in the Western region and 0 in New England.

Minimum Science Allowed for Entrance.

In addition to the minimum allowed when some science was

required, there were nearly 20 schools which specified that they would not accept less than 1 unit. Three schools permitted a minimum of ½ provided it was in certain specified sciences.

Schools Not Indicating Acceptable Science Subjects.

There were 81 schools which did not list acceptable sciences. These are by percentage of total for regions as follows: 5% for New England; 25% for Middle States and Maryland; 36% for North Central; 20% for Southern and 44% for Western. Many of these, particularly in the North Central and Western regions, stated that they accepted their students from accredited high schools and that what had been taken in high school was considered satisfactory.

Table VII. The Number of Units Stated as Being Required or[2] Accredited for Each of the Sciences When these are Presented for Entrance.

Subject	1	½-1[2]	½	1-2[2]	1-1[2]	No mention	Total
Chemistry	148	20	0	2	4	33	208
Physics	155	15	0	6	0	27	206
Biology	71	16	2	1	2	27	119
Botany	63	64	19	2	0	32	180
Zoology	57	62	19	2	0	26	166
Gen. Science	44	39	2	0	2	13	100
Physiology[1]	19	46	51	0	0	20	137
Phys. Geog.[1]	48	60	13	0	0	23	143
Com. Geog.	3	3	4	0	0	4	14
Astronomy	1	3	19	0	0	5	28
Geology	8	18	11	0	0	8	45

[1]One school allows from ½to 1 ½ units.

[2]The first number represents the minimum units which can be offered in the given science and the second number represents the maximum number which will be accepted for credit.

It is evident from Table VII that for most of the sciences one unit is both the minimum and maximum amount which will be accepted for entrance. Several of the schools which accept from ½ to 1 unit in chemistry and physics state that only half credit is given when the course has been taken with insufficient or inadequate laboratory work.

A number of schools state that by a unit is meant the "Carnegie Unit" (15). This in point of time is equivalent to 5 periods per week throughout the year, or one-fourth of a year's total work. As to content the "Carnegie Unit" has definite requirements with respect to textbook, laboratory and scope for each of the older sciences.

Summaries.

1. Approximately 55 percent of the schools granting an A. B.

degree require some science for entrance. The schools of the east require science the least, those of the far west, the most.

2. The rank in frequency of the prescribed subjects for all schools is English, mathematics, history and civics, languages, and lastly science. The schools of the North Central and Western regions place science ahead of languages.

3. The state universities require science less frequently, the percentage being 47.6.

4. During the years from 1922 to 1927 there has been a slight decrease in the number of schools which require science for entrance, this change being from 60 percent to 55 percent.

5. During this same period there has been a decrease in the total number of units required in each of the other subjects.

6. About 9 percent of the schools require two units of science for entrance.

7. Science and other subject requirements are about the same for the various departments and courses of the Liberal Arts colleges. Those granting a B. S. degree had slightly higher requirements in science.

8. The *laboratory* sciences are preferred as entrance subjects.

9. Chemistry and physics are everywhere accepted as extrance subjects—in fact preferred.

10. Biology is mentioned as being accepted in 57 percent of the schools. It ranks third in the east with 80 percent.

11. Botany and zoology are third and fourth for the whole country with 86 and 79 percent of the schools stating that they accept them. Zoology ranks only sixth in the east with 60 percent.

12. General Science is mentioned as being acceptable in 48 percent of the schools of the country. The percentages for the east and the rest of the country are 20 and 57.

13. The choice of the required science is limited by 28 schools to the following sciences which are ranked in order of frequency: —chemistry, physics, botany, zoology, biology, physiology and general science.

14. The maximum number of units of science which could be offered for entrance averaged about four.

15. For each of the sciences one unit was the amount most frequently stipulated as the minimum and maximum credit accepted.

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BUOYANCY APPARATUS.

By Clarence B. Hill,

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A simple and effective piece of apparatus to show that the loss of weight of a body is equal to the weight of the liquid it displaces may be made as follows:

Procure a piece of planed stock of pine or other soft wood one and five-sixteenths inches square, and a little more than ten inches long. Its cross section will be almost exactly ten square centimeters. Bore a deep hole in the center of one end, and fit a cork to it. This is to be the bottom. Put a small screw eye in the center of the other end, or top. Load with shot or similar material until the weight of the whole is 250 grams. Paint it with waterproof paint and lay off lines around it at distances of five, ten, fifteen, twenty, and twenty-five centimeters from the bottom.

To use this block, suspend it from a spring balance and show its weight to be 250 grams. Lower it into water to the five centimeter mark and show that the reading of the spring balance is now 200 grams. Continue in this way until the twenty-five centimeter mark is reached, when the reading of the balance is zero and the block is floating. It is hardly possible for any pupil to escape the conclusion that for every fifty cubic centimeters of wood immersed there is a loss of fifty grams in weight of the block.

TEACHING ONE THEOREM IN PLAIN GEOMETRY BY THE PROJECT METHOD.[1]

By T. E. Treutlein, Jr.,
San Diego, Calif.

We hear a great deal of project method work in various school subjects, and of teaming project method work with new type tests, but only infrequently is it possible to bring concrete examples of such an effort to the attention of teachers at large. The present discussion is a detailed presentation of such an effort. The writer trusts that it may be of some value to mathematics teachers.

Part I—Plane Geometry Project.

Project: To provide a stimulus for studying the Pythagorean Theorem, and for developing the formulas for an equilateral triangle and a hexagon by presenting a specific problem, a solution of which will necessitate a study of the above-mentioned forms.

Grade: Sophomore, in high school. (Students who have a knowledge of elementary algebra and one semester of plane geometry.)

Subject: Remarks—Very few high school students have the same proclivity for mathematics as Pythagoras or Newton. To most of them, working a theorem or deriving a formula in geometry is just so much valuable energy wasted. If the high school teacher can awaken an interest in the class by demonstrating that there is a real need for knowledge of geometry in this world, the gods will reward him.

There is a definite difference between a manual and intellectual project. Mathematics, especially in the secondary school, lends itself distinctly to the latter type of project. While the problem in this project is presented as a manual one, its successful solution must be worked out in the classroom with pencil, paper, ruler, and protractor.

Problem: A large radio antenna pole is to be erected on the grounds of a technical institution. The most suitable method of guying the pole is to use six guy wires—(see Figure I). The stakes to which the wires are secured are to be planted thirty feet from the base of the pole. It is necessary to find the area enclosed by the figure so that it can be determined how much of the grounds will be available for other purposes.

[1]This work was completed in two classes in educational tests and measurements and the curriculum taught by M. E. Broom in the San Diego State Teachers College.

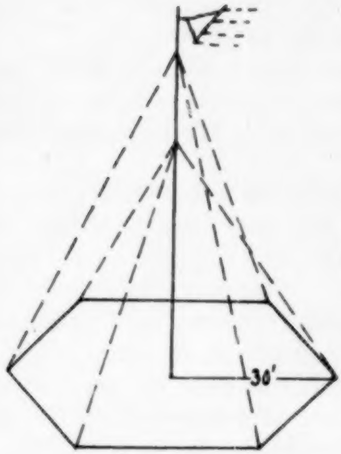


FIGURE I

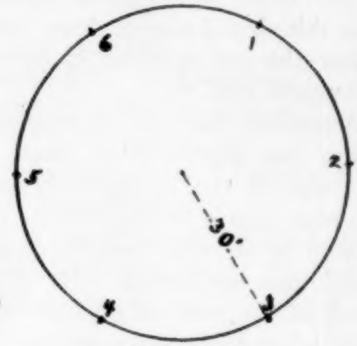


FIGURE II

Materials: 1. One large stake. Six smaller stakes. Hand ax. 2. Tape measure and a forty foot length of cord. 3. For each pupil—drawing paper, pencil, ruler, compass, and protractor.

Procedure: The class is acquainted with the problem in the classroom. Then the pupils are taken out to the school grounds and the large stake, called the "antenna pole," is driven. A smaller stake, thirty feet from the "antenna pole," is driven and the immediate question is how to drive the five other stakes so that they will form the vertices points of a regular hexagon.

The plan of using the "antenna pole" for the center of a circle of radius 30 feet will be inevitably suggested. When the class has reached this decision draw the circle by driving a heavy nail in the center stake and using the cord as a compass "arm." The circumference of the circle is found by the formula $2\pi R$ (which is known to the students). The result is divided by six and the other five stakes are located by measuring out the distance on the traced out circumference with the tape measure. At this point, the logical thing to do is to impress on the class the *inaccuracy* of this procedure. Return to the classroom and request the class to duplicate the work to scale on drawing paper (see Figure II).

A question should now be put to the class somewhat as follows: How may the circumference of *any* circle be accurately divided into six parts?

(a) If a pupil suggests dividing the 360 degrees of the circle

into six parts, this should be done. (Incidentally, here is the opportunity for drill in the use of the protractor.)

(b) If another suggests laying off the radius with the compass this should also be done. Should neither of these reactions follow the put question it necessarily is the instructor's duty to suggest one.

Assuming that (a) is suggested, the class should draw a figure (see Figure III). Since the radii lines and lines AB, BC, etc. of the hexagon (explain term) appear to be equal, the next step is to prove them so. This may easily be demonstrated by showing that the isosceles triangles are equi-angular and hence equi-lateral. (It is understood, of course, that as much of the work as possible should be done by the students. Only when there is a complete lack of suggestions on the part of the students should the instructor do the work.) Thus, a convenient method of dividing the circumference of a circle into six parts has been discovered; i. e. by using the radius length on the circumference, by means of the compass or dividers. Now take the class outside and demonstrate the new method on the traced out circle and correct the errors made in the original inaccurate placement of the stakes. Your figure is accurate—the next problem is to find its area.

The first reaction of the class to this problem will be to find the areas of the equal triangles AOB, BOC, etc. and total them, for from previous geometry lessons the pupils will have as the formula for the area of a triangle, $A = \frac{1}{2}ab$ (where a = altitude and b = base).

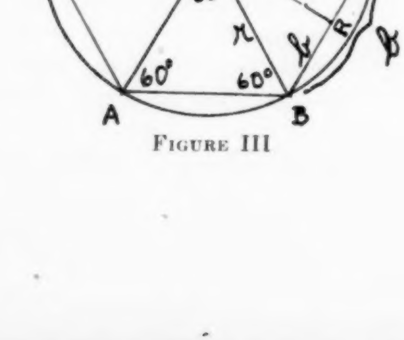


FIGURE III

Draw altitude a (see Figure III). Now, both a and b are unknown but the method of finding them is simple.

Method: BO and CO are equal (they are radii of the same circle).

RO and RO are equal (they are identical).

$\angle$OBC equals $\angle$OCB (triangle BOC is equiangular).

$\angle$ORB equals $\angle$ORC (RO being an altitude is perpendicular to line BC, the base).

Hence $\angle$BOR equals $\angle$COR (when 2 $\angle$s of a triangle equal 2 $\angle$s of another triangle, their 3rd $\angle$s are equal).

This proves that triangles BOR and COR are equal (because two sides and the included angle are respectively equal).

Therefore BR equals RC (corresponding sides of equal triangles are equal).

And, since BC equals the radius or thirty feet, BR equals b of triangle BOR or fifteen feet.

The equation for the area of the triangle now stands as $A=\frac{1}{2}a(15)$ (substituting the value for b). a remains to be found. Here, the equation derived from the Pythagorean Theorem in the form a^2 plus $b^2=c^2$ should be postulated by the instructor. By algebraic transposition this becomes $a^2=c^2-b^2$ or $a=\sqrt{c^2-b^2}$.

At this time the Pythagorean Theorem should be proved. The proof of this theorem is mainly a problem in construction and is not difficult (see Figure IV for construction and outline of proof).

We now possess both a and b of the Area equation and substitution gives the area of the triangle BOR as 194.85 square feet. Area of triangle BOC is twice that or 389.70 square feet, and the area of the hexagon will be six times the area of one of the six equal triangles, or 2338.20 square feet.

Suggest to the class the greater speed and accuracy that would result in computing the area of the hexagon if its area could be found by means of a formula. This may be developed as follows:

(1) $a^2=c^2-b^2$ (but $b=\frac{c}{2}$ in triangle BOR where $r=c$)

(2) Then $a^2=c^2-\frac{c^2}{4}$ or $a^2=\frac{3c^2}{4}$

(3) $a=\frac{c}{2}\sqrt{3}$ and $b=\frac{c}{2}$

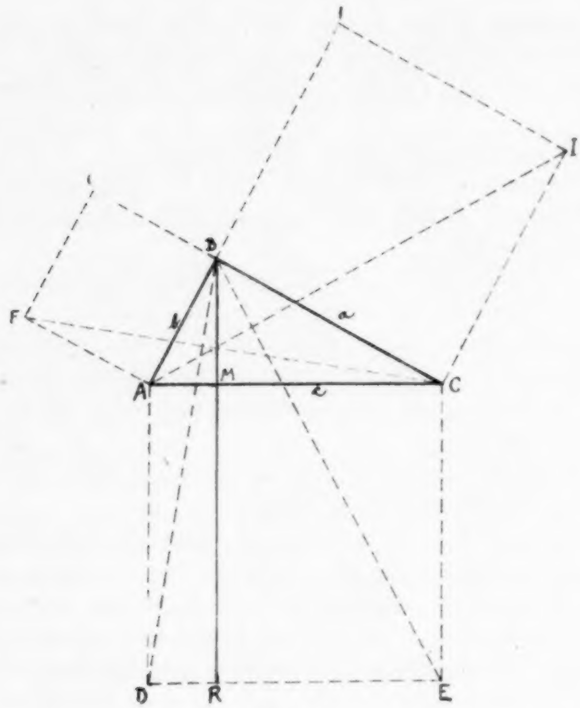


Figure IV

(4) Substituting values for a and b in $A = \frac{1}{2}a$, $A = \frac{c^2}{8}\sqrt{3}$

(5) Area of triangle BOR $= \frac{c^2}{8}\sqrt{3}$, then area of triangle BOC $= 2$BOR or $\frac{c^2}{4}\sqrt{3}$.

(6) The area of the hexagon would be six times this or $\frac{3c^2}{2}\sqrt{3}$

(7) A more suitable form of this formula is $\frac{3r^2}{2}\sqrt{3}$ (Substituting r for c, in this case equal).

Now demonstrate to the class the value of knowing the formula by giving one half the class a problem in finding the area of a hexagon by the old method and the other half using the formula. The result will be eloquent.

Anticipated Educational Result.

1. By presenting a specific, possible situation the students will be impressed by the fact that geometry exists *outside* of the textbook.

2. One problem is presented which *logically* calls for knowledge of several geometric theorems for its solution. This demonstrates the relationship of the forms.

3. Undoubtedly the facts which have been learned will be *remembered* longer because of their purposeful use, and they will be easily *recalled* because of the association with the specific problem.

4. Possibly a greater *interest* in secondary mathematics will be engendered.

Outline of Proof of the Pythagorean Theorem.

Given: Any right triangle ABC

To Prove: That a^2 plus $b^2 = c^2$ or that BHIC plus AFGB = ACED

Proof: Draw altitude BM and continue it to R.

1. Prove triangles FAC and DAB equal. From this step show that rectangles AFGB and DAMR are equal.

2. Prove triangles BCE and ACI equal. As in *1* show that rectangles BHIC and RMCE are equal.

3. It follows from the preceding that AFGB plus BHIC equals ACED.

(Note: The instructor should demonstrate the advantages of substituting a^2, b^2, and c^2 for BHIC, AFGB, and ACED respectively.)

Part II—Test on Plane Geometry Project.

Part A—Identification of geometric figures.

Given: eight geometric figures—A, B, C, D, E, F, G, and H.

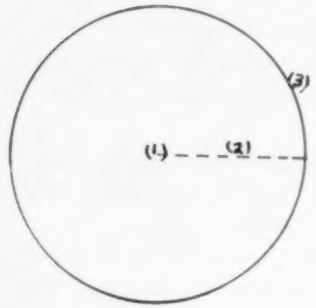
Directions: *Print* the names of the figures printed on opposite page in the correct spaces below.

Figure A.. ____________________

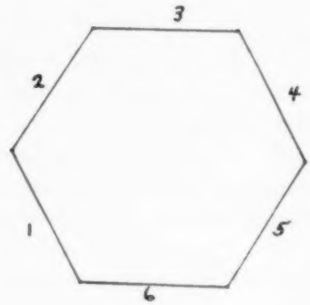
Figure B..
(sides 1, 2, 3, and 4 are equal) ____________________
(the angles are right angles)

Figure C..
(sides 1 and 2 are unequal) ____________________
(the angles are right angles)

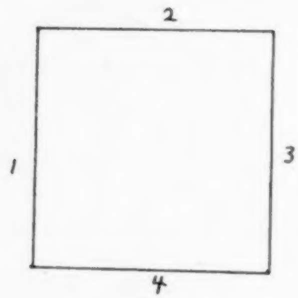
Figure D..
(sides 1, 2, 3, 4, 5, and 6 are equal) ____________________



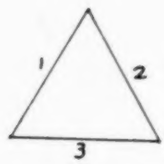
A



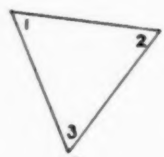
D



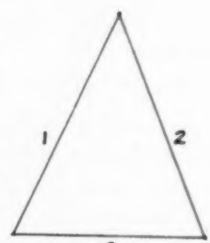
B



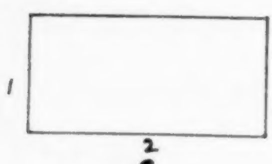
E



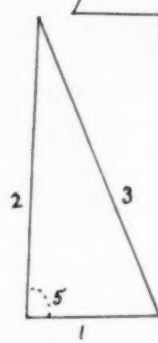
F



G



C



H

Figure E..
(sides 1, 2, and 3 are equal) ____________________
Figure F..
(angles 1, 2, and 3 are equal) ____________________

Figure G..
(sides 1 and 2 are equal) ____________________
Figure H..
(angle 5 is equal to 90 degrees) ____________________

Number of answers possible.................................. 8
Subtract number wrong.................................. –

Score..

Part B—Labeling parts of figures.

Directions: *Print* the names of the parts of the figures called for in the spaces provided below.

(N. B.—Figures A, B, C, and H are the only ones called for; the rest are omitted.)

Figure A
(1)..
(2)..
(3)..

Figure B
(1)..
(4)..

Figure C
(1)..
(2)..

Figure H
(1)..
(2)..
(3)..

Number of answers possible.................................. 10
Subtract number wrong.................................. –

Score..

Part II. *Scoring Key—Part A*	Part II. *Scoring Key—Part B.*
CIRCLE	*Figure A* center of circle, radius, circumference
SQUARE	
RECTANGLE	*Figure B* altitude, base
HEXAGON	
EQUILATERAL TRIANGLE	*Figure C* altitude, base
EQUIANGULAR TRIANGLE	
ISOSCELES TRIANGLE	*Figure H* base, altitude, hypotenuse
RIGHT TRIANGLE	

PART III—COMPLETION TEST ON PLANE GEOMETRY PROJECT.

Directions: Supply the word or formula in each blank space below which best completes the thought of the sentence.

1. In the algebraic representation of the Pythagorean Theorem c is equal to ....
2. Two triangles are equal if two .... and the .... of one are equal respectively to two .... and the .... of the other.
3. The .... of a circle divided by 2π equals the ....
4. When two sides of a triangle are equal, that triangle is said to be ....
5. A convenient method of dividing the .... of a circle into .... parts is to lay off the radius on it.
6. A regular hexagon is a .... sided figure having equal .... and equal ....
7. The general formula for the area of a regular hexagon is ...., where .... is one side of the figure.
8. In equal triangles .... sides are equal.
9. A .... may be drawn with a compass.
10. In equal triangles, a side, if common to both triangles, is said to be ....
11. The general formula for the .... of an .... triangle is $\frac{r^2}{4}\sqrt{3}$ where r is a .... of the triangle.
12. An equilateral triangle is also ....
13. A figure built up of six equilateral triangles with apexes meeting in a common point, is a ....
14. The general formula for the area of an equiangular triangle is ....
15. In similar triangles .... angles are equal.
16. To prove the truth of the Pythagorean Theorem it is necessary to show that the .... constructed on the .... of the triangle is equal to the sum of the .... constructed on the .... and .... of the triangle.
17. The truth of the Pythagorean Theorem is applicable only to .... triangles.
18. The formula for the area of any .... is $A = \frac{l}{2}ab$.
19. The area of a triangle is equal to .... the area of a rectangle of equal .... and ....
20. The .... of a triangle is perpendicular to its ....

Possible number of answers 39
Subtract total number of errors .... –

Score ....

PART III.

Scoring Key.

1. $\sqrt{a^2}$ plus b^2
2. sides (or angles), included, angle (or side), sides (or angles), included, angle (or side).
3. circumference, radius
4. isosceles
5. circumference, six

6. six, sides (or angles), angles (or sides)
7. $\frac{3}{2}r^2\sqrt{3}$, r
8. corresponding
9. circle
10. identical
11. area, equilateral, side
12. equiangular
13. hexagon
14. $\frac{r^2}{4}\sqrt{3}$
15. corresponding
16. square, hypotenuse, squares, base (or altitude), altitude (or base)
17. right
18. triangle
19. one-half, base (or altitude), altitude (or base)
20. altitude (or base), base (or altitude)

(Note: The test can be scored by comparing the given answers with a form such as the preceding. Possibly a more rapid means of scoring would be (a) to construct a window stencil or (b) to type the answers on transparent linen drawing cloth which could then be placed directly over the test form.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
University of Oklahoma, Norman, Okla.

Put off your imagination, as you take off your overcoat, when you enter the laboratory; but put it on again, as you do your overcoat, when you leave the laboratory.—*Claude Bernard, French physiologist.*

He who would do some great thing in this short life must apply himself to the work with such a concentration of his forces as, to idle spectators, who live only to amuse themselves, looks like insanity.—*Foster.*

Of science and logic he chatters,
As fine and as fast as he can;
Though I am no judge of such matters,
I'm sure he's a talented man.
—*Wintrop Mackworth Praed, "The Talented Man."*

They may say what they like; everything is organized matter. The tree is the first link of the chain; man is the last. Men are young; the earth is old. Vegetable and animal chemistry are still in their infancy. Electricity, galvanism,—what discoveries in a few years.—*Napoleon I.*

That the universe was formed by a fortuitous concourse of atoms, I will no more believe than that the accidental jumbling of the alphabet would fall into a most ingenious treatise of philosophy.—*Jonathan Swift.*

A THREE-TRACK PLAN FOR PHYSICAL SCIENCE AND ALLIED COURSES.

By George Forster,

Pasadena High School and Junior College, Pasadena, Calif.

Any scheme for a three-track system in the physical science courses should include among other things:—

1. A similar and mutually co-ordinated plan for courses which can properly be classed as pre-requisite to or supplementing those in physical science.

2. An adequate yet simple, just and easily interpreted basis for classifying students into the three divisions which such a system implies.

3. A ready and convenient means of transfering students frequently from one division to another, especially in the junior high school grades.

4. Courses of study adapted to and meeting the needs of the students in each division, yet so inter-related one with the other that transfer from one division to another is easily facilitated.

5. A method of supervision which will assure putting into effect the above features and provide the necessary co-ordination throughout the junior-senior high school and junior college grades.

The attached plan in graphic form aims to meet these requirements.

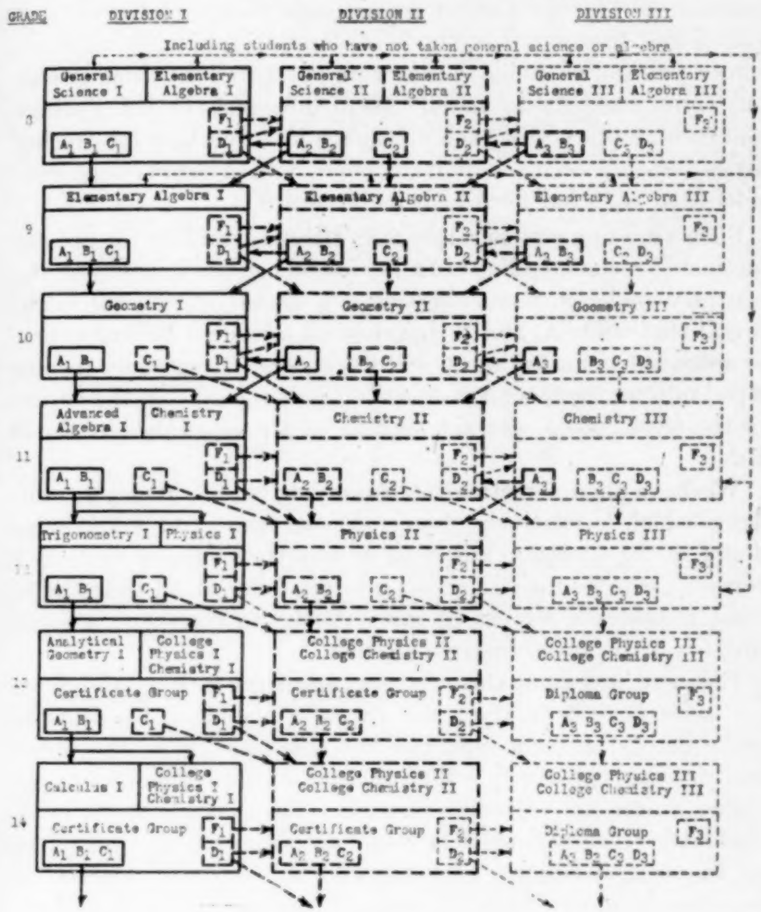
Since mathematics is fundamental to all of the physical sciences and with them forms the basis for the successful pursuance of engineering and research work the first of the three divisions is intended primarily for those students who have special aptitude and ability in general science and mathematics and who show fairly definite promise of becoming successful workers in the fields of pure and applied physical science.

The second division is planned for those students who show average ability in general science and mathematics and who aim to take up work for which the physical sciences may be pre-requisite but not essentially as fundamental or necessary as in engineering and research work.

The third division is designed for students who may not meet the requirements of the other divisions yet desire to derive the benefits and experiences incident to contact with certain physical science courses that may better prepare them to meet their problems in life. Such courses open to all students otherwise qualified would offer no college recommending grades.

OUTLINE OF A PROPOSED THREE-TRACK PLAN FOR PHYSICAL SCIENCE AND ALLIED COURSES

Note- Transfers from division to division in a given grade are made monthly, quarterly or at the end of semesters. Promotions to other grades are made yearly or in case of individual progress whenever a given course is completed.



It is assumed that transfer from one division to another or promotion from grade to grade shall be based on achievement alone and that any other classifying devices such as intelligence tests, character traits, etc., shall have been applied prior to a student's admission to the eighth grade. The object of this is to insure a simple and precise means of enabling students at any and all times to know exactly where they stand in relation to any division, its aims and requirements without introducing unnecessary complications and uncertainties. For this purpose the grades A, B, C, D and F are used in all of the divisions,

distinction among these being accomplished by attaching the sub-numerals 1, 2 and 3 respectively. It should be distinctly understood that these grades are insignia used for classification purposes and for the present are not concerned with the existing varied and haphazard methods of deriving them. It thus becomes possible not only to segregate students into three groups but simultaneously to classify them into best, better, average and poor groups within each division, a feature which for psychological reasons seems important enough to demand more consideration than has been hitherto accorded it.

Such a grading system rather than affecting unfairly the present method of recommending students for college work should on the contrary make it more effective. A glance at the form will reveal that while A_1 and B_1 recommend a student for either first or second division college work, C_1, A_2 and B_2 will only recommend him for the second division. It is supposed that the nature of the work would warrant making C_1 the equivalent of A_2 or B_2.

We have then a method of classifying and segregating students which is relatively simple, definite and just; it leaves no doubt in the students' minds as to why they happen to be in a certain grade and division and informs them at all times as to what requirements must be met in order to remain in a given division or be transferred to another.

Frequent and comparatively easy transfers both up and down are made possible in the lower grades to enable all students to make desired adjustments, but the requirements in the upper two divisions gradually stiffen so that upward transfers in the higher grades are no longer possible. For example an A_2 or B_2 student in General Science II would automatically be transferred up to General Science I at the end of a month, quarter, or semester, or promoted to Elementary Algebra I at the end of the year, while on the other hand a D_1 student in General Science I would be transferred down to General Science II or promoted to Elementary Algebra II. Transfer upward is still possible from Division III to Division II in the eleventh grade, but no transfers upward would be made beyond that time.

Students who desire to take any of the third-division physical science courses in the eleventh and twelfth grades need not necessarily take general science and mathematics as pre-requisites but would be eligible at the proper time regardless of previous training.

It should also be possible to use such a plan for either group or individual progress.

Space and time do not permit going into detail relative to the courses offered in each division but a single illustration should suffice to make the idea clear. Suggested pre-requisites, minimum requirements and objectives for courses in physics are outlined below. The essential things to keep in mind in formulating such requirements are the adaptation of the subject-matter to the needs and interests of the respective groups and the coordination of the work of each division in such a manner that transferred students can readily adjust themselves to changed conditions.

Proposed Requirements for Courses in Physics.

Physics I.

Pre-requisites

Course	*Division*	*Grade*	*Division*	*Grade*	*Division*	*Grade*
General Science	I	A_1 B_1 C_1	II	A_2 B_2	III	A_3 B_3
Elementary Algebra	I	A_1 B_1 C_1	II	A_2 B_2	III	A_3 B_3
Geometry	I	A_1 B_1	II	A_2		
Advanced Algebra	I	A_1 B_1				
Chemistry	I	A_1 B_1				
Trigonometry*	I	A_1 B_1				

*May be taken in same year with physics.

A_1 and B_1 in physics are recommended grades for engineering and intensive physical science courses in college.

C_1 in physics is a recommended grade for general college science courses.

College courses in the first and second divisions grant credit toward certification for upper division work in universities.

D_1 students in physics may enroll in College Physics III and College Chemistry III. These courses grant credit toward the junior college diploma but not toward certification for upper division work in universities.

D_1 and F_1 students may be transferred to Division II at any time during the year.

General Course Requirements.

Lecture, conference and class work of an advanced nature with special emphasis on scientific method and the preparation of students for engineering and intensive college physical science courses.

Laboratory work of an advanced nature including individual and class projects.

Problems to receive special emphasis.

Demonstrations to be given by students before this and classes in other divisions.

Physics II.

Pre-requisites

Course	*Division*	*Grade*	*Division*	*Grade*	*Division*	*Grade*
General Science	I	D_1	II	A_2 B_2 C_2	III	A_3 B_3
Elementary Algebra	I	D_1	II	A_2 B_2 C_2	III	A_3 B_3
Geometry	I	C_1 D_1	II	A_2 B_2 C_2	III	A_3
Chemistry	I	C_1 D_1	II	A_2 B_2	III	A_3

A_2 and B_2 in physics are recommended grades for general college science courses. These courses grant credit toward certification for upper division work in universities.

C_2 and D_2 students in physics may enroll in College Physics III and College Chemistry III. These courses grant credit toward the junior college diploma but not toward certification for upper division work in universities.

D_2 and F_2 students may be transferred to Division III at any time during the year.

General Course Requirements.

Lecture, conference and class work of a general nature with emphasis on important fundamental physical principles and laws and their applications.

Laboratory work of a general nature to illustrate these principles and laws, including individual and class projects.

Problems of a general nature involving these principles and laws.

Demonstrations given by the instructor and by students in Physics I, with students in Physics II assisting.

Physics III.

Pre-requisites.

Students who have reached the eleventh and twelfth grades will as a rule be admitted, including any who have completed one or several of the following courses but failed to receive grades better than those indicated.

Course	*Division*	*Grade*	*Division*	*Grade*
General Science	II	D_2	III	C_3 D_3
Elementary Algebra	II	D_2	III	C_3 D_3
Geometry	II	D_2	III	B_3 C_3 D_3
Chemistry	II	C_2 D_2	III	B_3 C_3 D_3

Students in this course cannot receive a grade which will recommend them for college work of certificate grade.

General Course Requirements.

Lecture, conference and classwork relating in a very general way to important fundamental physical laws and principles with special emphasis on their applications in household and other well-known devices.

Laboratory work of a very general nature illustrating these applications and including individual and class projects.

Demonstrations given by the instructor with the assistance of students in Physics II and Physics III.

Any changes as radical as the introduction of a multiple-track system, the adoption of the junior-senior high school idea and the establishment of a 6-4-4 plan should involve equally drastic changes in methods of supervision and administration. The old scheme of departmental control in each school no longer seems adequate to meet the demands imposed by the new order of things and a more unified and co-ordinated plan of procedure throughout the schools becomes desirable. Widely varying methods of instruction in the same or similar courses of study, unnecessary duplication of equipment, lack of uniformity and efficiency in procuring supplies and apparatus, improper arrangement and inefficient use of classroom and laboratory space, and especially inconsistent and diverse standards of testing, grading and classifying students are a few of the things which intensive study and a more centralized organization could improve. While it is not necessarily inferred that the present department-head method should be entirely abolished it does seem essential to supplement it to a great extent by a much broader, more unified and centralized control. Some of our branches of education, notably music, manual arts, and physical education, have had such supervision a number of years. Should not subjects as important as mathematics and physical science receive at least as much consideration? Would not this situation be met by having a "Director of Mathematics and the Physical Sciences" who would be qualified to administer and supervise the contents of courses, methods of instruction, and procurement of supplies and equipment throughout the elementary, junior-senior high school and junior-college grades? He should by training, interest and experience be in a position to foresee and meet the needs and problems of students in all the grades, be thoroughly familiar with the demands imposed by the pure and applied sciences in the universities and especially in the industries, be able to correlate and articulate the work of his department with that of others, to effect the establishment of a uniform system of testing, grading and classifying students, and insofar as his department is concerned aid the superintendent in establishing and carrying out sound educational policies.

BOB-WHITE AND SCARCITY OF POTATO BEETLES.

By E. L. Moseley,

State Normal College, Bowling Green, Ohio.

For more than ten years Ohio has protected Bob-white with a closed season, and a great increase in the numbers of these birds may be seen. If we may judge the abundance of the birds by the frequency with which they are observed by human eyes, we would say that Bob-white is now fully twenty times as numerous as when there was an open season. These birds have, however, not only multiplied, but have become so tame that they do not take the trouble to keep out of sight. The apparent increase may be due, therefore, as much to their tameness as to their actual increase. Students in my classes have come to the State Normal College from all counties of northwestern Ohio, and also from other parts of the State. Not one among them knew of any county where the Bob-white had failed to increase in recent years. Most of them would not attempt to estimate the extent of increase; some thought tenfold, others two, three, or fourfold.

For several years past potatoes have been raised successfully on many farms in Ohio without spraying for beetles, or taking any measures to combat the insects. In fact many patches have been practically free from the "bugs." I have never known of the potato grower being so fortunate in previous years. For more than half a century the Colorado potato beetle has been a very serious pest wherever potatoes were raised. Why it should disappear I could not explain. I had wondered if ladybirds, which fed upon the eggs of this beetle, had multiplied; or if some other enemy was holding it in check. The Rose-breasted Grosbeak is so uncommon here that few people ever see one. A captive mole which I fed for some time would not eat potato beetles, either larvae or adults. These insects are not relished by all the birds and mammals that greedily devour white grubs and grasshoppers.

Last year while cutting weeds on the farm where I had first noticed the scarcity of potato beetles, I discovered a Bob-white's nest near the potato patch. I reflected that these birds had probably found breeding places and been numerous near this potato patch for several years. In the city of Sandusky, where Bob-white is presumably uncommon, I had helped a friend in gathering hundreds of beetles from his small patch of potatoes.

I decided to make further observations and inquiry.

Close to the much-traveled Chicago Pike I noticed a potato patch badly infested with beetles, while other potato patches which I examined showed few or none. Most of the farmers I talked with reported seeing few potato beetles in recent years. So I enlisted the help of my students in making further observations and inquiries. Below is given a summary of the information thus collected.

Bob-whites have been observed to spend much of the time among the potato vines.

They have been seen to follow a row, picking off the potato beetles.

When the potato patch was located near woodland there was no trouble with the beetles; but when the patch was near the highway or buildings, even on the same farm, the insects were troublesome.

On farms where the Bob-white found nesting sites and protection, the potato vines, if not too near the buildings, were kept free from the insects.

A patch of potatoes surrounded by open fields, without bushes, tall weeds, or crops that might shelter the Bob-white, was likely to be infested with beetles.

A farmer living eight miles south of Defiance raised about fifty Bob-whites on his place. During the two years that these birds were there he had no trouble with insects on either potatoes or cabbage. The following autumn a number of the birds were killed by hunters, while others were frightened away. The next summer the potato beetles were back in numbers. The farmer is again raising Bob-whites and protecting them from hunters.

A student coming from Potsdam, in northern New York, reports that they have no Bob-whites, and that potato beetles are plentiful. Another reports from western Pennsylvania, where the Bob-white is not as plentiful as in Ohio, potato beetles are still very numerous. E.H. Forbush wrote me from Massachusetts as follows: "When the Bob-whites were most plentiful on my farm they kept the potato beetles in check, so that we did not have to spray at all; and I have heard of several other similar instances."

More recently I have learned from A. F. Conradi, General Manager of the Southern States Chemical Co., Birmingham, Alabama, that in the truck growing regions of the south a greater quantity of arsenical spray (calcium arsenate) is used for potato

beetles than for any other insect. He also states they have an open season for shooting the Bob-white.

It has been suggested that this evident scarcity of potato beetles may be due in part to the work of the Hungarian Partridge. It is true that these imported birds have become common on many Ohio farms, and some credit may be due them. But the Bob-white is much more generally distributed, and its habits are much better known; and we are much more inclined to regard this species as the principal cause of the recent scarcity of the potato beetle in Ohio.

PROBLEM DEPARTMENT.

Conducted by C. N. Mills,
University of Michigan, Ann Arbor, Mich.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, 204 Mason Hall, University of Michigan, Ann Arbor, Mich.

LATE SOLUTIONS.

1034. *L. Wayne Johnson, Norman, Okla.*
1036. *Robert C. Weaver, Spokane, Wash.*

SOLUTIONS.

1037. *Proposed by George Sergent, Tampico, Mexico.*

Suggested by 1010. A cubical box, side 10 inches internally is half full of water. What is the diameter of a ball, which can be put in and just covered with water?

Solved by Robert Hecktman, Spokane, Wash.

Let R be the radius of the ball. Then 2R is the depth of the water in the box. Hence

$$\frac{4}{3}(\text{pi})R^3+500=100\times 2R$$

or $$R^3-47.745R+119.3625=0.$$

Solving by Horner's method gives $R=3.1624$, or $2R=6.3248$ in.

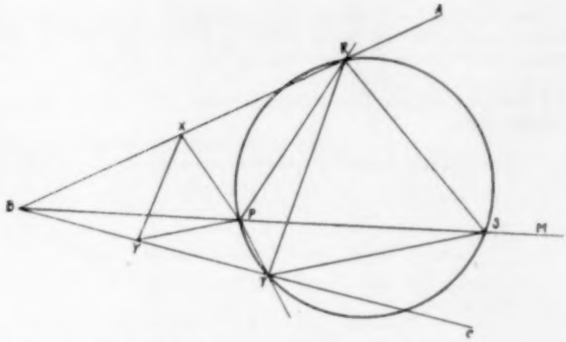
Also solved by *S. M. Turrill, Chicago, Ill.; R. L. Calvin, Youngstown, Ohio; Carlton Jencks, Spokane, Wash.;* and the *Proposer.* One incorrect solution received.

1038. *Proposed by M. Freed, Los Angeles, Calif.*

Within a given angle A inscribe an equilateral triangle having a given point P as a vertex. P is not on the side of the angle.

Solved by Kate Bell, Spokane, Wash.

Let ABC be the given angle, and P the given point. Draw BPM; construct angles MPR and MPT each equal to 60°. Pass a circle through R, P and T, cutting BM at S. Draw triangle RTS; draw PX parallel to RS and PY parallel to ST; join X and Y. Then PXY is the required triangle.



Proof. BX/XR = BP/PS and BY/YT = BP/PS. Hence BX/XA = BY/YT, and XY is parallel to RT. Then triangles XYP and RTS are similar, corresponding sides are parallel. Since triangle RTS is equilateral, the triangle PXY is equilateral.

Also solved by *F. A. Cadwell, St. Paul, Minn.;* and *George Sergent, Tampico, Mexico.*

1039. *Proposed by Norman Anning, University of Michigan.*

Solve the following equation:

$$\frac{1}{x+1} - \frac{2}{x+2} + \frac{1}{x+3} = 0.$$

I. *Solved by H. G. Ayre, Waukegan, Ill.*

$$\frac{1}{x+1} - \frac{2}{x+2} + \frac{1}{x+3} = 0x^3 + 0x^2 + 0x - a = 0$$

The roots of right equation are infinite.

II. *Solved by Raymond Huck, Johnston City, Ill.*

If we substitute $1/y$ for x in the given equation, we get an equation whose roots are each zero. Hence x = infinity is the solution of the given equation.

Also solved by *P. H. Nygaard, Spokane, Wash.* Two incorrect solutions received.

1040. *Proposed by the Editor.*

Establish the following relation which is found in *Solution IV* of Problem 1021 in November issue, page 889.

$$r_a = 4R\sin(A/2)\cos(B/2)\cos(C/2).$$

I. *Solved by Kate Bell, Spokane, Wash.*

See Figure on page 889, November issue.

$$\text{SinF} = \text{Sin}\frac{A}{2} = \frac{EB}{2R}, \text{ and } 2R\sin\frac{A}{2} = EB. \qquad (1).$$

$\angle I^1BG$ is the complement of one-half $\angle ABC$, hence

$$\cos\frac{B}{2} = \frac{r_a}{BI^1}. \qquad (2).$$

$\angle I^1CD$ is the complement of one-half $\angle ACB$, hence

$$\cos\frac{C}{2} = \frac{r_a}{CI}. \qquad (3).$$

Multiplying (1), (2) and (3) we get

$$2R\sin\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2} = \frac{EB\cdot r_a^2}{BI^1\cdot CI^1}. \qquad (4).$$

$d=2EB$. Also, $CI \cdot BI' = 2EB \cdot r_a$ (The product of two sides of a triangle is equal to the product of the altitude on third side and the diameter of the circumscribed circle. Substituting in (4) we get the required relation.

II. *Solved by George Sergent, Tampico, Mexico.*

In any triangle ABC

$$\sin A + \sin B + \sin C = 4\cos\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}, \qquad (1);$$

$$2R = \frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = \frac{a+b+c}{\sin A + \sin B + \sin C},$$

$$2R = \frac{2s}{4\cos\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}}, \qquad (2);$$

$$r_a = s\tan\frac{A}{2}, \qquad (3).$$

Dividing (2) by (3), we get

$$2R : r_a = 2s : 4\cos\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}s\tan\frac{A}{2}$$

Canceling $2s$ and substituting $\sin\frac{A}{2}$ for the product $\cos\frac{A}{2}\tan\frac{A}{2}$ we obtain

$$2R : r_a = 1 : 2\sin\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}, \text{ whence}$$

$$r_a = 4R\sin\frac{A}{2}\cos\frac{B}{2}\cos\frac{C}{2}.$$

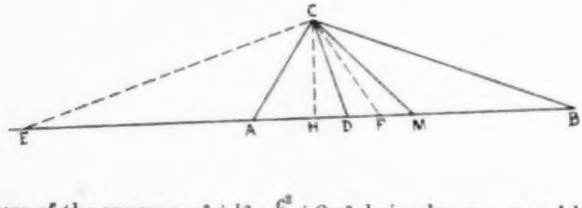
Also solved by *S. M. Turrill, Maywood, Ill.; R. E. Morris, Spokane, Wash.;* and *F. A. Cadwell, St. Paul, Minn.*

1041. *Proposed by George Sergent, Tampico, Mexico.*

The base of triangle, the median and the internal bisector from the opposite vertex are given. Show how to compute the other two sides.

Solved by the Proposer.

Let A B C be the triangle; $CM=m$, the median; $CD=l$, the bisector; E, the point where the external bisector meets the base $BA=c$; CH the altitude; F the midpoint of MD.



The sum of the squares, $a^2+b^2=\frac{c^2}{2}+2m^2$, being known, a and b could be computed if the product ab, or the ratio $a:b$, or the difference a^2-c^2, were known. Any of these can be found if MD is determined, for

$$1). \quad ab = l^2 + BD \cdot AD = l^2 + \left(\frac{c}{2}+MD\right)\left(\frac{c}{2}-MD\right) = l^2 + \frac{c^2}{4} - \overline{MD}^2;$$

2). $a : b = BD : AD = \left(\frac{c}{2}+MD\right) : \left(\frac{c}{2}-MD\right)$;

3). $a^2-b^2=\overline{BH}^2-\overline{AH}^2$, and $BH=\frac{c}{2}+\frac{MD}{2}+FH$, $AH=\frac{c}{2}\left(\frac{MD}{2}+FH\right)$,

and FH is determined by $m^2-l^2=2\ MD\cdot FH$.

Let $MD=x$, and $CE=y$. AB is divided harmonically in D and E. Therefore $\overline{MA}^2=MD\cdot ME$, which is $\frac{c^2}{4}=x\cdot ME$, whence $ME=\frac{c^2}{4x}$, and DE $=ME-x=\frac{c^2-4x^2}{4x}$.

Consider the $\triangle$ MCE and the line CD. By *Stewart's* relation $\overline{CM}^2\cdot DE+\overline{CE}^2\cdot MD-ME\cdot DE\cdot MD=\overline{CD}^2\cdot ME$; $m^2\frac{c^2-4x^2}{4x}+y^2\,x-\frac{c^2}{4x}\cdot\frac{c^2-4x^2}{4x}\cdot x=l^2\cdot\frac{c^2}{4x}$.

Multiply by $16x$, and simplifying we get $16y^2x^2-16m^2x^2+4c^2x^2=4l^2c^2-4m^2c^2+c^4$. (1).

In the right $\triangle$ DCE, $\overline{CE}^2=\overline{DE}^2-\overline{CD}^2$, which is $y^2=\left(\frac{c^2-4x^2}{4x}\right)^2-l^2$, whence $16y^2x^2=c^4\ 8\ c^2x^2+16\ x^4-16\ l^2x^2$.

Substituting in (1), we get after rearranging $(4x^2)^2-(c^2+4m^2+4l^2)\,(4x^2)+4c^2\,(m^2-l^2)=0$, equation of the problem, which yields

$$x^2=\frac{1}{2}\left[\left(\frac{c^2}{4}+m^2+l^2\right)-\sqrt{\left(\frac{c^2}{4}+m^2+l^2\right)^2-c^2\left(m^2-l^2\right)}\right].$$

x^2 and x are found from the data, and a and b can be computed by one or the other of the methods suggested.

1042. *Proposed by E. de la Garza, Brownsville, Texas.*

The sides of a triangle are three consecutive integers, and the largest angle is twice the smallest angle. Find the sides.

I. *Solved by S. S. Snell, Kansas City, Mo.*

$$\frac{\text{Sin } 2A}{\text{Sin } A}=\frac{2\sin A\cos A}{\sin A}=\frac{x+2}{x}\cdot \text{ (Law of Sines).}$$

$$\text{Hence, } \cos^2 A=\left(\frac{x+2}{2x}\right)^2 \qquad (1)$$

$$\frac{\text{Sin } (180°-3A)}{\text{Sin } A}=\frac{\sin 3A}{\sin A}=\frac{x+1}{x}\cdot \quad \text{(Law of Sines).}$$

Sin $3A=3\sin A-4\sin^3 A$, hence

$$3-4\sin^2 A=\frac{x+1}{x}$$

$$\text{or } \sin^2 A=\frac{2x-1}{4x}. \qquad (2).$$

Adding (1) and (2) we get

$$\frac{2x-1}{4x}+\left(\frac{x+2}{2x}\right)^2=1. \qquad (3)$$

The solution of (3) gives $x=4$, hence the sides of the triangle are 4, 5 and 6.

II. *Solved by Sudler Bamberger, Harrisburg, Pa.*

$$\frac{\text{Sin } 2A}{\text{Sin } A}=\frac{x+2}{x}, \text{ hence } \cos A=\frac{x+2}{2x}.$$

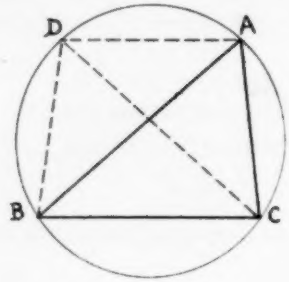
By Law of Cosines

$x^2=(x+1)^2+(x+2)^2-2(x+1)\ (x+2)\cos A.$

Substituting for cos A, and simplifying we get $x^2-3x-4=0$. Hence $x=4$, and the sides of the triangle are 4, 5 and 6.

III. *Solved by George Sergent, Tampico, Mexico.*

Let ABC be the triangle in which $\angle C=2\angle B$. $AB=a+1$, $AC=a=1$,



$BC=a$. Let D be the point where bisector of $\angle C$ meets the circumcircle. The chords BD, DA and AC are equal, each subtending an angle equal to $\angle B$. Since the isosceles triangles ABD and CDA are equal, AB = CD.

By *Ptolemy's Theorem.*

$BC\cdot AD+BD\cdot AC=AB\cdot CD$; hence

$a\ (a-1)+(a-1)^2=(a+1)^2.$

Solving gives $a=5$, then $AB=6$, $AC=4$.

Also solved by *A. Nicolson, San Jose, Calif.; R. E. Morris, Kate Bell, Spokane, Wash.; Clyde Bridger, Ivar Highberg, William Blashfield, Walla Walla, Wash.; H. D. Grossman, New York, N. Y.; S. M. Turrill, Maywood, Ill.; Raymond Huck, Johnston City, Ill.; H. G. Ayre, Waukegan, Ill.; F. A. Cadwell, St. Paul, Minn.; and the Proposer.*

PROBLEMS FOR SOLUTION.

1055. *Proposed by E. de la Garza, Brownsville, Texas.*

Prove that 12^n-11_{n-1} is a multiple of 121.

1056. *Proposed by R. L. Calvin, Youngstown, Ohio.*

Suggested by 1037. A hemispherical bowl, inner diameter 10 in., is half full of water. What is the diameter of a ball which can be put in and just covered with water?

1057. *Proposed by Secran.*

Each of the n digits of a number is 3. Prove that the square of the number is formed by writing in a row, from left to right, $(n-1)$ 1's, one 0, $(n-1)$ 8's, and one 9.

1058. *Proposed by the Editor.*

If in a triangle ABC angle $C=60°$, prove

$$\frac{1}{a+c}+\frac{1}{b+c}=\frac{3}{a+b+c}$$

1059. *Proposed by Howard D. Grossman, New York, N. Y.*

If S_n be the sum of the legs and h_n the hypotenuse of an integral right triangle in which the legs differ by unity, then

$$(1+\sqrt{2})^{2n+1}=S_n+h_n\sqrt{2}$$

gives all possible pairs of values for S_n and h_n.

1060. *Proposed by George Sergent, Tampico, Mexico.*

Prove that any focal chord of a parabola is equal to four times the focal radius of the point of contact of the tangent parallel to the focal chord.

AIDS FOR THE TEACHING OF SCIENCE.

By J. H. Jensen, *Northern Normal and Industrial School, Aberdeen, So. Dak.*

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COURSES FOR PHYSICS TEACHERS AT GEORGE PEABODY COLLEGE FOR TEACHERS.

In 1927 George Peabody College for Teachers published a bulletin of "Suggested Curricula" in twenty-two different departments. "Each curriculum prepares for a specific type of teaching position." The Department of Physics was established at that time and its "Suggested Curricula" consists of a four year undergraduate course and a three year graduate course. The four year course contains not only content courses in physics, mathematics and chemistry, but also courses in education, psychology, etc. and "Materials and Methods of Teaching Physics in the High Schools." The graduate curriculum contains not only the advanced courses in the subject matter of physics, but also courses in the "Materials and Methods of Teaching Physics in the Normal Schools and Colleges." Besides these the graduate student is expected to do research work in either the methods and technique of teaching physics or some phase of the subject matter of physics.

As long as physics was taught at Peabody College during the summers only, too few courses were offered to enable a graduate student to make it his major subject. However, as soon as the Department of Physics was established, with courses running throughout the year, a few students began on research problems. Two graduate students completed their theses and the other requirements for the M. A. degree in August, 1928. Rather interesting and surprising results were presented in each of these theses. In one of them, "A Comparison of Grades in College Physics," Josiah Crudup presents the effects of having had, or of not having had, physics in the high school, upon the grades made in College Physics. In the other thesis, "The Preparation of High School Teachers and Their Students' College Records," Horace B. Sharitz compares the records of students in College Physics with the type of training of the teachers of these students in High School Physics. Several investigations in the methods of teaching physics are now in progress. We consider this the most important function of such a department in a college for teachers.

THE PASSING OF THE MAFFIA.

Facts About the Picturesque Sicilian "Secret Society."

Mussolini and the Fascist Government of Italy have, it is reported, dealt a death blow to the "secret society" known as the maffia (sometimes spelled mafia). Some say the group is not really eliminated; others believe that it has indeed passed, and that with it has gone much crime and violence that heretofore has kept fairly well out of the clutches of the law.

The maffia, as a more or less vague group, has gathered about it various legends and traditions. It has frequently been the subject of romantic fiction. The actual state of affairs to which the word refers, however, is summarized by Webster's New International Dictionary as follows:

"In Sicily, the popular sentiment of hostility to the law, leading to refusal to bear witness in case of crime, and hence to frequent violent crimes, especially against persons, as officers, who have incurred popular displeasure; also, a body of persons imbued with this sentiment."

Pictured as a powerful secret society, the maffia has often been regarded by the romantically inclined as comparable to Robin Hood's band of Sherwood Forest in English folklore. Those sympathizing with the maffia, in fact, did foster the notion among the poor of Sicily that the maffia would protect the weak from aggression, and, in the manner of the fabled Robin Hood, would rob the rich to feed the poor.

RADIO RECEPTION IN 1929.

The poorest radio reception for many years may be expected during the latter half of 1929 because of the large number of spots on the sun due at that time, Prof. Harlan T. Stetson of the Harvard Laboratory of Astronomy predicted when he described three years of researches connecting radio receiving conditions on earth with changes in the atmosphere of the sun.

One of the reasons that radio broadcasting developed so rapidly is that at the time of its rapid growth, about 1923, sun spots were at a minimum and at no time since has radio reception been so favorable, Prof. Stetson explained. Equally good receiving conditions will not return again until the present sun cycle terminates in 1934.

The popular impression that radio reception is universally poor in summer and good in winter is "completely unfounded," Prof. Stetson declared. If shortened days and decreased daylight which aid radio were the only factors, the popular idea would be correct, but during the winters of 1926 and 1927 increased activity on the sun made the cold seasons better radio periods than the summers. Decreases in sun spots during the last two months of this year have improved receiving conditions greatly. Prof. Stetson explained that static due to thunder storms in summer causes the average radio listener to decrease his set's sensitivity and thus appear erroneously to get low signal intensity in warm weather.

A definite fourteen to fifteen month period in both radio and solar activity was discovered by Prof. Stetson's researches conducted in cooperation with Greenleaf W. Picard of Newton Center, Mass. One of these secondary maxima falling due next September or October and coinciding with the longer sunspot cycle of about eleven years will probably make the sun more spotted and the radios more unhappy than they have been for years.—*Science News Letter.*

CHEMISTRY OF MOTION PICTURE FILM.

By Dr. R. E. Rose,

E. I. du Pont de Nemours & Co., Wilmington, Del.

The story of their love, their sorrow, their despair, and the triumph of their happiness was a moving one, appealing to the longing for romance that is in the hearts of all. Those who read it in the pictures, and they were multitude, never thought that the story was written in silver with a pen of light.

On every reel should appear the mystic chemical symbols describing this method of writing, as important in many ways as the discovery of the alphabet. These symbols tell us that silver (Argentum) bromide passes over into silver metal and bromine. It so happens that this chemical change is accelerated enormously by light. It also happens that the chemist devoting himself to photography is able to produce silver bromide in a form that is tremendously sensitive though stable enough for commercial use. Thus it is quite possible to take pictures in a 20,000th of a second. The light waves traveling at 186,000 miles per second strike the little clumps of silver bromide in the gelatin of the film and shatter some silver loose from the bromine. When the film is put into a developer more silver is separated from the bromine but the process starts from the points already shattered by the light. When the process is complete the brightest spots in the picture are represented by a mass of tiny specks of black silver. The scene is reversed, it is now a negative. When light is again passed through this onto a new film the original light effect is produced and that is the picture.

At first these little specks of silver bromine were put on glass plates; they had to be on something transparent and glass was the only transparent substance available. It was possible to make records with photography at this stage of its development but the moving picture was out of the question.

Then came the discovery that cotton could be made into nitrocellulose, that nitrocellulose could be dissolved, and that when the solution was mixed with camphor a transparent plastic was formed. This transparent plastic is flexible, glass is not. This difference made the modern movie possible. Fortunately it happens that silver is a very permanent material, and so are gelatin and the transparent plastic if properly kept, so that we may look forward to very permanent records, actually in silver, of the doings of humanity, fictitious as well as real.

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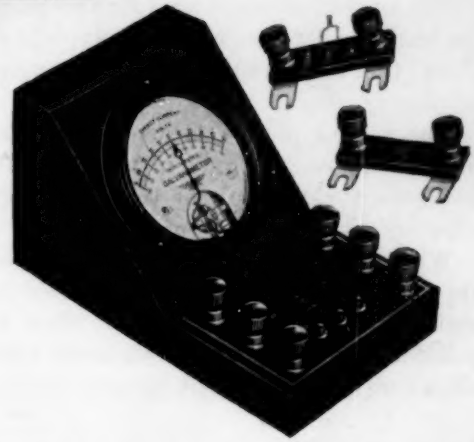

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The moving picture theatre is built around the achievements of the chemist, not only in the film but in the source of light used, the evolution of the tungsten-lamp being a very brilliant chapter in the triumphs of chemistry.

When next you see the tragedy or comedy of the screen add the chemist to those great ones named as producers and actors, and think of the tiny specks of silver whose shadows make it possible for your eyes to see so many entertaining stories. After all, where would the sheik be without the chemist?

REPORT OF SPECIAL COMMITTEE ON PROFESSIONAL TRAINING.

Adopted at the Annual Meeting of the Central Association of Science and Mathematics Teachers, Dec. 1, 1928.

Your committee was appointed last spring with the understanding that a final report would not be made at this time. This preliminary report is made, therefore, to report progress and to express the hope that the work will be continued.

As a body of teachers of science and mathematics we are in a position to understand and appreciate the value of research in pure and applied science and mathematics and to comprehend its profound influence upon the thought and life of our own generation. We are in sympathy with the recent emphasis in educational circles on equal opportunity for all. But we are also keenly aware of the many problems which have developed in our efforts to educate the masses in an age of progress unparalleled in human history. The old objectives are giving way to new aims in education. The subject matter content of our courses is changing. Classroom procedures are being modified. Research in education, which is giving us a better understanding of the educative process, is placing a greater emphasis on methods of teaching. The training of the classroom teacher has become, therefore, a very vital factor in our present system of education.

The Central Association has in the past made valuable contributions to the cause of secondary education. In these new developments there is an opportunity for the Association to perform an equally if not more magnificent piece of work. As a

body of classroom teachers we are primarily responsible for the solution of our own problems. We need to devote some time aside from our regular duties, therefore, to the study of such problems as the aims and methods of teaching, the subject-matter content of courses, the preparation of teachers, etc., in the departments represented by the Association.

Within our own as well as other organizations there is already a disposition to cooperate in such an undertaking that is very encouraging. It has been proposed by one organization of secondary school teachers that the Central Association, because of the unique position which it occupies in the states of our area, assume a sort of leadership in securing the cooperation of the educational bodies so that in a combined effort the most desirable results might be obtained. Herein lies both an opportunity and a responsibility. It is our earnest hope that the Central Association will lend its support to these significant developments.

The problem which should have first consideration, in the judgment of your committee, is the training of secondary school teachers. Some of the other problems mentioned above might even be included in this major problem. Therefore it is recommended, and I move

FIRST, that the present committee be continued and that it be empowered to collect data regarding teacher-training requirements in the various states of our area; regarding conditions which prevail in the institutions in which teachers receive their training; and regarding the type of training which will give the best preparation for teachers of science and mathematics in our secondary schools,

SECOND, that the committee be empowered to invite cooperation and specific suggestions from departments of education and departments of science and mathematics in the various teacher training institutions,

THIRD, that the committee be empowered to cooperate with other bodies in the solution of our common educational problems,

FOURTH, that the committee be empowered to enlarge its membership with the advice and consent of the Board of Directors of the Association,

FIFTH, that the Board of Directors appropriate a reasonable sum to defray the expense of preparing questionnaire material, mailing it to and from the committee and other necessary correspondence, and,

SIXTH, that the committee be directed to make specific recommendations to this body at the next annual meeting looking toward the unified action of our membership in this matter.

Respectfully submitted,
ROBERT N. AUBLE,
G. W. WARNER,
J. M. KURTZ, Chairman,
Committee.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department.

School examinations are particularly desired. Send with your papers now.

A CALL FOR HELP.

528. *From Katherine Delperdang, Hawarden, Iowa.*

"Please send to me a book on simple electrical, physical or possibly chemical stunts or ideas appropriate for introductory meetings of our high school physics club. Electrical stunts are preferred."

Send titles of books, with publisher's name, or titles of articles with references so that they may not only be relayed to Miss Delperdang but also be published in SCHOOL SCIENCE AND MATHEMATICS as a permanent record.—[Editor.]

529. *Proposed by Sudler Bamberger, 730 South 27th Street, Harrisburg, Pa.*

Dear Mr. Jones:

I desire to propose the following problem: A motorist, traveling on a level road at forty miles per hour, sees something ahead. He applies his brakes on the car and comes to a stop with a uniform acceleration. If he stops in thirty seconds, how far did he travel before coming to a stop?

SOLUTIONS AND ANSWERS.

526. (This problem was written on the board in a room occupied by the Society for the Promotion of Engineering Education with the caption "Type of Problem for Home Work.")

Hanging over a pulley there is a rope with a weight at one end; at the other end hangs a monkey of equal weight. The rope weighs 4 oz. per foot. The combined ages of the monkey and its mother are 4 years and the weight of the monkey is as many pounds as its mother is years old The mother is twice as old as the monkey was when the mother was half as old as the monkey will be when the monkey is 3 times as old as its mother was when she was 3 times as old as the monkey was. The weight of the rope and weight is half as much again as the difference between the weight of the weight and the weight of the weight plus the weight of the monkey. What is the length of the rope?

Solution sent in by John C. Packard.

My dear Franklin T.:

Merry Christmas and a Happy New Year.

Can you stand another word about the monkey problem? A very efficient teacher of Algebra in our school insists that her pupils handle such problems by analysis, observing what happens to each person or thing mentioned in the problem and making up equations accordingly. I enclose two pages from her. One showing her plan of analysis for the pupil and another, giving a rather more detailed solution as she would solve it for herself.

Analysis by Pupil.

AGE

	Monkey		*Mother*	
Now	$3a$	(8)	$5a$	(7)
Was	$\frac{5a}{2}$	(6)	$\frac{9a}{2}$	(5)
Will be	$9a$	(3)	$11a$	(4)
Was	a	(1)	$3a$	(2)

$$8a=4$$
$$a=\frac{1}{2}$$
$$5a=\frac{5}{2}$$

WEIGHT

	Rope	*Weight*	*Monkey*
Length	$4L$		
Weight	L	$\frac{5}{2}$	$\frac{5}{2}$

$$L+\frac{5}{2}+\frac{15}{4}$$
$$L=\frac{5}{4}$$
$$4L=5$$

Ans. 5 ft.

Solution by Analysis by Miss Anna R. Liden, High School, Brookline, Mass.

Let Monkey's youngest given age $= a$
Mother's youngest given age $= 3a$
2nd Monkey's age ("will be") $= 9a$
Difference between Monkey's ages $= 8a$
$\therefore$ 2nd Mother's age $= 11a$
3rd Mother's age ("was") $= \frac{9a}{2}$
Difference between Mother's ages $= \frac{13a}{2}$
$\therefore$ 3rd Monkey's age $= \frac{5a}{2}$
4th Mother's age ("now") $= 5a$
Difference between Mother's ages $= \frac{a}{2}$
$\therefore$ 4th Monkey's age $= 3a$

$$\therefore 8a=4$$
$$a=\frac{1}{2}$$
$$5a=\frac{5}{2} \text{ years in Mother's age now}$$

Let Weight of rope in pounds $= L$
Length of rope in feet $= 4L$
Weight of Monkey $= \frac{5}{2}$
Weight of weight $= \frac{5}{2}$

$$L+\frac{5}{2}=\frac{15}{4}$$
$$L=\frac{5}{4}$$
$$4L=5$$
$$\therefore \text{Length of rope} = 5 \text{ ft.}$$

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BOOKS RECEIVED.

Modern Physics by Charles E. Dull, Head of Science Department, West Side High School, Newark, New Jersey. Cloth. Pages viii+778. 12x18.5 cm. 1929. Henry Holt and Company, New York.

Outdoor Adventures by Albert E. Shirling, Department of Natural Science and Geography, Teachers College, Kansas City, Missouri. Cloth. Pages vi+250. 13x18.5 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $1.00.

Applied Arithmetic for Girls by Nettie Stewart Davis, Girls' Trades and Technical High School, Milwaukee, Wisconsin. Cloth. 126 pages. 13x19.5 cm. 1928. The Bruce Publishing Company, Milwaukee, Wisconsin. Price 88 cents.

General Science Course for Seventh, Eighth and Ninth Grades by Joseph R. Lunt and Dennis C. Haley, The Teachers College of the City of Boston. Cloth. 31 units, 14 now ready for distribution. 21.5x27 cm. L. E. Knott Apparatus Company, Cambridge, Massachusetts.

Course of Study in General Science, Biology, Chemistry, Physics for Montana High Schools. Prepared and issued under the direction of The State Department of Public Instruction. 1928. Paper. 92 pages. 14.5x23 cm. Helena, Montana.

American Council Solid Geometry Test, Form A and American Council Trigonometry Test, Form A by Henry W. Raudenbush, Instructor in Mathematics, Columbia, L. Parker Siceloff, Associate Professor of Mathematics, Columbia University and Ben D. Wood, Associate Professor and Director Bureau of Collegiate Educational Research, Columbia College, Columbia University. Solid Geometry Test has two parts, Part I having 92 true-false statements and Part II 28 problems. Trignometry Test is in four parts as follows: Part I, 37 multiple-choice questions; Part II, 24 true-false statements; Part III, 28 short answer questions; Part IV, 22 short answer questions. Price each test per package of 25 with directions, key and class record, $1.25. Specimen Set of each test, 20 cents. World Book Company, Yonkers-on-Hudson, New York.

BOOK REVIEWS.

The Elements of Industrial Engineering, by George Hugh Shepard, Professor of Industrial Engineering and Management, Purdue University, Lafayette, Indiana. Cloth. Pages xii+541. 14.5x23 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $4.80.

This book was prepared for use as a textbook in industrial engineering classes. The aim of the author has been to lead the student to analyze the management situations he meets and to apply certain definite principles in their solution. These principles are all included in the general principle designated by the author as the principle of "higher common sense." This is divided into three primary and nine secondary principles. These principles are taught by having the student apply them to situations met in his daily class work, and extra-curricular activities. Proper planning, correct methods, adaptation of conditions, fair dealing, discipline, etc., are all repeatedly illustrated and practiced in school life. Exercises drawn both from campus activities and from industry, giving practice in the applications of the principles follow each chapter.

G. W. W.

The New World, Problems in Political Geography by Isaiah Bowman, Ph. D., Director of the American Geographical Society of New York. Fourth Edition. 257 Maps. Cloth. Pages v+803. 15.5x24 cm. 1928. World Book Company, Yonkers-on-Hudson, New York. Price $4.80.

For those who want to know what the great world problems in political geography and history are, and who do not have time to make an extensive study of these vital and interesting questions, The New World offers a brief, but reliable and understandable survey. It is written by an authority on the subject who has carefully noted all the changes brought about by the World War and who has analyzed the important aspects and presented his analyses in a style suited to the average student of contemporary affairs.

The book starts with those problems common to or directly affecting all the great powers such as debts and reparations, control of raw materials, distribution of land, mandates and colonies, limitation of armaments, etc. This general view of world affairs is followed by an analysis of the specific problems of each of the main political divisions and of each of the smaller related groups. The final chapter reviews the problems of the United States. More than two hundred and fifty maps are used to show geographical divisions, religions, languages, density of population, routes of trade, etc. The book is well adapted for general reading and reference or for use as a class textbook for college courses in political geography and world politics. Students in other countries will be interested in the accurate and nonpartisan discussions of their political, commercial and economic problems. G. W. W.

Elementary Calculus, by Frederick S. Woods and Frederick H. Bailey, Professors of Mathematics in the Massachusetts Institute of Technology. Revised Edition. Cloth. Pages x+385. 13.5x20.5 cm. 1928. Ginn and Company, 15 Ashburton Place, Boston. Price $3.00.

It is only in recent years that writers of textbooks of mathematics have taken cognizance of the fact that many serious students soon lose interest in a subject in which they can see no practical value. "The spirit is willing but the flesh is weak." Faith in the real value of the subject is lost before the utility of the subject is reached. The student becomes bewildered by the mass of detail to be accumulated before he is permitted to make use of any of the tools he had acquired. This is especially true of the calculus. Here is a textbook of calculus that is different in this respect. The authors start with practical problems on average speeds and develop the definition of speed as a limit. Acceleration is the next step. The process of differentiation starts on page 15, differentials are introduced on page 43, and the theory of integration is begun on page 56. Thus in the work of a few weeks the student has been conducted to the very heart of the subject, an attainment accomplished by many of the older books only after a half of the year had been spent in theorizing, memorizing and forgetting. Moreover, all through these fifty pages the student has been dealing with types of problems he has been meeting in his work in mechanics and is provided with a new offensive weapon. The book includes a considerable amount of analytic geometry thus making it possible to use it as a textbook for college freshman classes. G. W. W.

Objective Tests by Jacob S. Orleans, formerly of the Educational Measurements Bureau, New York State Department of Education, and Glenn A. Sealy, District Superintendent of Schools, Lewis County, New York State. Cloth. Pages x+373. 12.5x19.5 cm. 1928. World Book Company, N. Y. and Chicago. $2.20.

This book presents a plan for the local construction and use of objective tests, for instructional administrative and supervisory purposes. The necessary steps in the training of teachers, principals and superintendent in carrying out such a program form an important part of the first half of the book. The presentation is made concrete by describing in detail the carrying out of the plan in a rural school district. The book concerns itself exclusively with tests related to administrative and supervisory purposes of the grading of pupils and organizing the school, discovering at the same time the educational needs of the pupils and the instructional needs of the teachers. Class room tests as such—the diagnostic tests and the specific performance tests—are not in its field.

Types of objective questions are presented, multiple choice—single response, multiple choice—plural response, true—false, a completion type, the matching type, and the short answer type. The relative merits of each type of test are pointed out. The Appendix of over 100 pages offers much very valuable concrete material by way of local tests that were developed by the teachers and administered under the supervision of the authors in a system of schools in a rural district. These cover tests in reading, arithmetic, spelling, geography, history, nature study, physiology, language usage and grammar, grades 2 to 7. The Appendix

also includes record sheets, one for each school in the system, tabulating the achievement of each pupil within his school. These sheets form a convenient means for interpretation of results. The authors present a thoroughly sane testing program, sane because it is the product of the cooperative effort of the teachers local to the district in which it was administered. Profiting by their concrete experience the authors present an ideal testing program which can be carried out in any system of schools.

R. B. Z.

Experimental Physics, a Laboratory Manual, by Albert Edward Caswell, Ph. D., Professor of Physics, University of Oregon, ix+181 pages. 14x21 cm. Cloth. 1928. The Macmillan Company, N. Y.

This laboratory manual "has evolved simultaneously with the author's text book, AN OUTLINE OF PHYSICS, which it is intended to accompany." The manual may, however, be used in connection with any text book as only standard apparatus is required. This may be purchased from any scientific supply house. Many manuals have been criticized because the directions given for the performance of experiments have been so detailed that very little, if any, opportunity has been offered the student for initiative in the development of laboratory technique. Some times, it is said, such detailed directions, together with elaborately prepared tables for observed data, tend to keep a student at the level of a mere recorder. This surely is *not* such a manual. The directions are given only in general terms and tabular forms are conspicuous by their absence. Most experiments open with a paragraph of Preliminary Exercises designed to arouse in the student a proper appreciation of the work before him. Every experiment contains a section in which the *Principle of the Experiment* is discussed, and this is followed by the section *Work to be Done*. The manual is written in a clear common sense sort of way. There are 16 experiments in mechanics, 12 on heat, 18 on magnetism and electricity, 15 on light and 3 on sound. The Appendix contains Trigonometric and Logarithmic Tables, a note on Significant Figures and Computations, a note on Graphic Representation of Results, together with a very brief note on the vernier and the micrometer. A rather brief list of books to make up a reference library is added. R. B. Z.

SHOES FROM OLD TIRES.

In parts of the Near East the automobile age has brought a queer by-product shoe. Thousands of cast-off American automobile tires are imported, cut into pieces, and used as the soles for crude sandals. The "synthetic shoe" has also made its appearance. Cloth shoes with rubber soles have long been in use on tennis courts and gymnasiums. In recent years patented materials rivaling sole leather in toughness have been used as soles for some of the ordinary shoes made in America.

The greatest single factor in the development of modern shoes was the invention of shoe-making machinery. United States inventors were first in this field, and as a result the United States leads the world in shoe production. In 1926 more than 324 million pairs of boots and shoes were turned out by the factories of the United States. This one year's production was worth nearly a billion dollars.—*Geographic News Bulletin.*

CHICOPEE FALLS BRIDGE.

Newest of engineering marvels is the first steel railway bridge to be built without a rivet or a bolt, opened at Chicopee Falls, near Springfield, Mass., on the Boston and Maine Railroad. The span was constructed entirely by arc welding, with a saving of one-third in steel. The parts could be made smaller and lighter because they were not weakened by rivet and bolt holes. Moreover, much time and expense were saved. The completion of the bridge marks a step away from the noisy riveting gun.—Louis A. Wendelstein, at the November Meeting of Eastern Association of Physics Teachers.